

THE AYURVEDIC PHARMACOPOEIA OF INDIA

**PART - I
VOLUME- VII
(Minerals & Metals)**

First Edition



सत्यमेव जयते

**GOVERNMENT OF INDIA
MINISTRY OF HEALTH AND FAMILY WELFARE
DEPARTMENT OF AYURVEDA, YOGA & NATUROPATHY, UNANI, SIDDHA
AND HOMOEOPATHY (AYUSH)
NEW DELHI**



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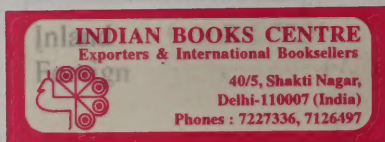
Quick ref.
BFS. 23

**PDH.66. Part I, Vol VII
5000-2008 (DSK II)**

©2008, Ministry of Health and Family Welfare
Government of India
Department of Ayurveda, Yoga – Naturopathy, Unani, Siddha & Homeopathy
(AYUSH)

Effective from 1st January, 2009

Price :



ISBN :

978-81-905952-2-3

Published by :

THE CONTROLLER OF PUBLICATIONS
CIVIL LINES, DELHI - 110054

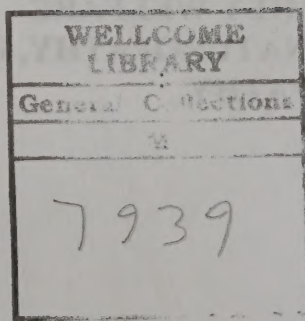
On Behalf of :

GOVERNMENT OF INDIA
DEPARTMENT OF AYURVEDA, YOGA-
NATUROPATHY, UNANI, SIDDHA AND
HOMOEOPATHY (AYUSH), INDIAN RED
CROSS SOCIETY BUILDING, SANSAD
MARG, NEW DELHI

WEBSITE :

www.indianmedicine.nic.in

Printed at



Cirrus Graphics Pvt. Ltd, New Delhi



मन्यमेव जयते

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MINISTRY OF HEALTH & FAMILY WELFARE

आयुर्वेद, योग व प्राकृतिक चिकित्सा,

यूनानी, सिद्ध एवं होम्योपैथी (आयुष) विभाग

DEPTT. OF AYURVEDA, YOGA & NATUROPATHY,

UNANI, SIDDHA AND HOMOEOPATHY (AYUSH)

रेड क्रॉस भवन, नई दिल्ली - 110001

RED CROSS BUILDING, NEW DELHI - 110001

FOREWORD

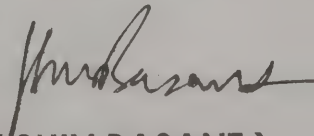
Ayurvedic Pharmacopoeia of India Part I, six volumes are compilations of monographs on single drugs commonly used in the practice of Ayurveda. This seventh volume of Ayurvedic Pharmacopoeia of India, Part-I consist of 21 monograph on Metals and Minerals used in Ayurveda. Though Metals and Minerals are used in other systems of medicine also, their use in Ayurvedic preparations is unique in view of the detailed Shodhan (detoxification) process contained in the Ayurvedic classical text.

The validation of all these processes requires the help of other related branches of science such as Geology, Organic and Inorganic chemistry, Analytical chemistry, Phytochemistry etc. Apart from this, advances in Nanotechnology are also important to provide a better understanding of the changed state of the Metals and Minerals after their processing by the recommended classical methods.

The genuine basic raw material is very much essential for quality medicines. Comprehensive tests and parameters for authenticity of raw materials have been described in this volume for the first time. This volume will be useful for the Pharmaceutical industry and Ayurvedic drug laboratories to assure the quality of drugs involving Metals/Minerals. Academicians, scientists and researchers engaged in this field will be also benefited from this publication.

This volume is the result of the untiring efforts of the expert members of Ayurvedic Pharmacopoeia Committee. The commitment and hard work of scientists from different organizations like IBM (Ajmer), NIA (Jaipur), members of APC, scientists and staff of APC cell at CCRAS Hqrs. and the Deptt. of AYUSH accomplishing this task is highly appreciated.

The Department of AYUSH, Ministry of Health and Family Welfare have great pleasure in presenting the seventh volume of the Ayurvedic Pharmacopoeia, Part I comprising of 21 monographs of quality standards of metals and minerals used in Ayurvedic medicines. Suggestions and comments for further improvement of the Pharmacopoeial work are welcome.


(SHIV BASANT)

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LEGAL NOTICES

In India, there are laws dealing with drugs that are the subject of monographs which follow. These monographs should be read subject to the restrictions imposed by these laws wherever they are applicable.

It is expedient that enquiry be made in each case in order to ensure that the provisions of the law are being complied with.

In general, the Drugs & Cosmetics Act, 1940 (subsequently amended in 1964 and 1982), the Dangerous Drugs Act, 1930 and the Poisons Act, 1919 and the rules framed there under should be consulted.

Under the Drugs & Cosmetics Act, the Ayurvedic Pharmacopoeia of India (API), Part-I, Vol. VII, is the book of standards for Single Drugs of Minerals, Metals and Marine origin included therein and the standards prescribed in the Ayurvedic Pharmacopoeia of India, Part-I, Vol. VII, would be official. If considered necessary, these standards can be amended and the Chairman of the Ayurvedic Pharmacopoeia Committee authorized to issue such amendments. Whenever such amendments are issued, the Ayurvedic Pharmacopoeia of India, Part-I, Vol. VII, would be deemed to have been amended accordingly.

GENERAL NOTICES

These General Notices provide basic guidelines to help, interpret the provisions and terms used in this volume, in connection with the implementation of the recommended standards and methods of tests prescribed therein. In addition, they also include the features of a monograph that are mandatory standards.

Title: The title of this book is "Ayurvedic Pharmacopoeia of India, Part-I, Vol.VII (Minerals and Metals)". Monographs on twenty-one raw drugs (minerals / metals / ores) are included in this volume.

Monograph: Each Monograph carries prescribed mandatory standards and general information, including those from Ayurvedic Classics. The Monographs are arranged in the English alphabetical order, based on the main Samskr̥ta official name.

Monograph Title: The title given on top of each monograph indicates the name of the material in Samskr̥ta, and is the same as mentioned in the single drugs list on the Ayurvedic Formularies for Minerals, Metals and Ores. It is the "*Official Name*" along with synonyms in Samskr̥ta. This is followed by a scientific nomenclature in English that is nearest and most appropriate to the article described, and is also "*Official*".

Synonyms: Taking into account the multilingual nature of the country, other names of the drug have been listed in Indian languages other than Samskr̥ta as far as these are available. The Urdu and Tamil equivalents, however, are those appearing for the same drug in their respective Formularies.

Broad Classification: The raw materials obtained from the earth's crust and used in the indigenous systems of medicines are of great complexity, being a mixture of various elements, compounds and **gangue** (waste rock i.e. the non-metalliferous part of an ore, not useful for the intended purpose). They may be chemically classified only in a broad sense, and exact chemical nomenclature cannot be assigned. Therefore, a broad classification, such as Silicate, Sulphide, Oxide and Metal etc., is added for basic information.

Origin and occurrence: The nature and forms in which a raw drug occurs in the earth's crust and its association with other minerals and rocks are included to give an idea about geology of the substance. The occurrence and availability of the article in India are also incorporated. This important information reflects the commercial potential of the article as a source for the drug required by the Ayurvedic, Siddha & Unani practitioners, and to the manufacturers.

Standards: For mandatory purposes, the statements made under the following headings in a monograph shall constitute "*Official Standards*", ...Title, Definition, Identification (Physical, Optical and Chemical properties), Tests and Assays, Distinction from substitutes and adulterants, Heavy metals, and the "Śodhana" process described and recommended in classics quoted in Appendix -5.

Physical Properties: These include nature, colour, streak, cleavage, fracture, lustre, tenacity, transparency, hardness, specific gravity, taste and magnetism. These are reliable and easy identification features for minerals and metals. Fluorescence and XRD analysis applied for identification of a few articles have also been included. Physical properties serve as the preliminary but powerful parameters for identification of raw drugs. Definitions of geological terminology used in the monographs and methods of determination of various parameters are given in Appendix-1.

Optical Properties: These include the application of optical crystallography in identification of minerals that are crystalline and transparent, irrespective of their chemical composition. This is a time-tested petrographic/ mineralogical method of analysis using thin sections of mineral or ore samples, but adapted and applied to powdered materials to suit pharmacopoeial requirement. Several parameters can be computed from only a few fragments using immersion liquids of known Refractive Indices, by a method known as the '*Immersion Method*'. Description of the principle and the method of determination of various constants are given in detail in Appendix-2.

Chemical Properties: Under this, confirmatory identification tests for raw drugs are mentioned. These include charcoal test, flame colouration test, effect of heat, solubility in water and acids and reaction with different acids. The most important, however, are determination of assays for major ingredients and minor constituents, presence of heavy metals and other elements of significance. Details of various tests and methods of determination of elemental assays etc., Details about Chemical & Reagents are given in Appendix-4.

General:

- a) Except a few very simple chemical tests which have been given in monographs, all methods of determination of physical, optical and chemical properties are given in detail in the Appendices.
- b) Instructions, explanations of technical terms, and the methods, given in different Appendices, are the standard ones employed in the identification of the ores, minerals, metals and inorganic substances. More than one method for determination of a particular parameter in a monograph is given in this volume and the choice of method to be adopted is left to the user, provided the actual method used is on record with laboratory data.

Miscellaneous:

Temperature: Except where specifically mentioned, ambient temperature in Celsius scale is intended.

Pressure: Atmospheric pressure of 760 torr at 0°, unless stated otherwise.

Weight and Measures: 'Constant Weight' implies that under the given circumstances, no two consecutive weights shall differ by more than 0.5 mg per gram of substance taken for analysis. '*Weight taken for analysis*' is the amount to be taken for quantitative analysis stated in the procedure within an approximate range, but shall be accurately weighed and shall not differ from the stated weight by more than 10 percent.

Abbreviations, used in the monographs, are given in a table on next page.

Abbreviations for Technical Terms

$^{\circ}\text{C}$	—	—	$^{\circ}$
$2^{\text{d}} \sin \theta$	—	—	$\eta\lambda$
analytical reagent	—	—	AR
atomic absorption spectrophotometry	—	—	A.A.S.
gram(s)	—	—	g
inductively coupled plasma analyser	—	—	ICPA
kilo newton (pressure unit)	—	—	kN
microgram(s)	—	—	μg
millilitre(s)	—	—	ml
milligram(s)	—	—	mg
nanogram(10^{-9} g)(s)	—	—	ng
nanometer(s)	—	—	nm
part(s) per million or gram(s) per tonne	—	—	ppm
precipitate	—	—	ppt.
quantity sufficient	—	—	Q.S.
refractive index	—	—	R.I.
refractive index	—	—	η
solution	—	—	sol.
specific gravity	—	—	Sp. Gr.
ultra-violet	—	—	UV
x-ray diffraction	—	—	XRD
x-ray fluorescence spectrometry	—	—	XRF

Abbreviations for Texts

Āyurveda Prakāśa	—	—	आ.प्र.
Bṛhat Rasarājasundara	—	—	बृ.र.रा.सु.
Bhāvaprakāśa	—	—	भा.प्र.
Caraka Saṁhitā Sūtrasthāna	—	—	च.सं.सू.
National Formulary of Unani Medicines	—	—	N.F.U.M.
Rasaprakāśasudhākara	—	—	र.प्र.सु.
Rasataranṅiṇī	—	—	र.त.
Rasaratnasamucchaya	—	—	र.र.स.
Rasendracintāmaṇi	—	—	रसे.चि.
Rasendracūḍāmaṇi	—	—	र.चू.
Śārṅgadhara Saṁhitā	—	—	शा.सं.
Siddha Bheṣaja Maṇimālā	—	—	सि.भे.म.मा.
Siddha Formulary of India	—	—	S.F.I.
Suśruta Saṁhitā Sūtrasthāna	—	—	सु.सं.सू.

INDO-ROMANIC EQUIVALENTS OF DEVANĀGARĪ ALPHABETS

अ	-	a	ड	-	ḍa
आ	-	ā	ढ	-	ḍha
इ	-	i	ण	-	ṇa
ई	-	ī	त	-	ta
उ	-	u	थ	-	tha
ऊ	-	ū	द	-	da
ऋ	-	r̥	ध	-	dha
ए	-	e	न	-	na
ऐ	-	ai	प	-	pa
ओ	-	o	फ	-	pha
औ	-	au	ब	-	ba
·	-	m̐	भ	-	bha
:	-	ḥ	म	-	ma
क	-	ka	य	-	ya
ख	-	kha	र	-	ra
ग	-	ga	ल	-	la
घ	-	gha	व	-	va
ङ	-	ṅa	श	-	śa
च	-	ca	ष	-	ṣa
छ	-	cha	स	-	sa
ज	-	ja	ह	-	ha
झ	-	jha	क्ष	-	kṣa
ञ	-	ña	त्र	-	tra
ट	-	ṭa	ज्ञ	-	jña
ठ	-	ṭha		-	

PREFACE

Ayurveda is very much rich in many aspects and the number of drugs and their sources. The use of a few minerals and metals in Ayurvedic medicines is since Vedic period but scientific and systematic studies were conducted from 8th century onwards forming an integral part of Ayurvedic medicines called *Rasaśāstra* and the formulations called *Rasyogas*.

The brief history of *Rasaśāstra* reveals many aspects of this science when viewed in perspectives of identification, *Śodhana* (Purification), *Māraṇa* (Calcination), indications and dietetic regimen.

Caraka has used 'Rasa' in *Kustha cikitsā* but it is not sure whether it is *Pārada* or else. Six metals viz. *Svarṇa*, *Rajata*, *Tāmra*, *Loha*, *Varṇa* and *Nāga* have been coined under drugs of mineral origin. These metals have been indicated for preparation of different devices like *Bastinetra*, *Dhūmanetra*, etc. Specialized procedures like *Lohādi Rasāyana*, *Ayaskṛti* have been described so that these metals can be converted into a consumable and efficacious dosage form for therapeutic use. For this, the thin sheets of metals are repeatedly heated and quenched in a series of liquids viz. *Triphalā kvātha*, *Gomūtra*, *Godugdha*, *Lavaṇajala*, etc. until conversion to fine powder. Apart from metals, various other minerals like *Gandhaka*, *Svarṇamāksika*, *Haritāla*, *Maṇḥsilā*, *Maṇḍūra*, *Gairika*, etc.; alloys viz. *Kāṁsya*, *Pittala* and gems viz. *Muktā*, *Pravāla* have been mentioned for therapeutic and other uses. Suśruta, in addition to all this, has used *Pārada* (first non-ambiguous reference) tropically.

Aṣṭāṅgasaṅgraha, for the first time, clearly indicates administration of *Pārada* for its *Rasāyana* effect. Blowing up metal in a crucible to convert into powder form has also been described by him.

Almost of the marked developments of *Rasaśāstra* have taken place in this period (from 8th century A. D.). The science attended its peak of advancements and opened new horizons in the field of medicine. Several *Rasasiddhas* (disciples of *Tāntrika* doctrine) have contributed to this process. The outcomes of their extensive experimentations have been documented in the form of texts. *Nāgārjuna* was the most significant contributor to establish the aims, principles and methodologies of *Rasaśāstra* in an organized and systematic manner. Numerous texts viz. *Rasaratnākara*, *Rasendramāṅgala*, *Rasārṇava* have been composed in this period explaining *Śodhana*, *Māraṇa*, properties, therapeutic uses, dose specifications and various formulations of *Rasauśadhis*. The *Śodhana* and *Māraṇa* methods may either be characteristic for some specific material or applicable to a group/category. Moreover,

specifications for construction of a pharmacy have also been given instructing specific directions for specific procedures and arrangements required inside and outside the pharmacy campus.

Mainly three types of Physical treatments are adapted in metal/mineral preparations i.e. Heat, Beat and Treat. Here the treat means the material is treated with many organic preparations, the sequence of physical treatments may be varied considering the type of material and formulation but the sequence may get changed.

In compiling the monographs, the title of each drug had been given in Sanskrit as already obtained in the Ayurvedic Formulary of India. Then comes the definition physical properties / Explanations of Geological/ Technical terms – Terminology used in pharmacopoeial Monographs and methods of determination of the drug giving its identity in scientific nomenclature and very brief information about its source, occurrence, distribution and precautions in collection if any, etc.

This is followed by a list of synonyms in Saṃskṛta and also the other Indian regional languages. The monographs then record the Definitions and Methods of determination of different optical parameters followed by Chemical properties along with qualitative chemical tests of minerals by Blow pipe method. Apart from this, the distinct photographs of all included materials are exhibited.

Since the efforts is to compile pharmacopoeial monographs of Ayurvedic drugs, in the accent of the classical attributes of respective drugs according to the doctrine of *Rasa*, *Guṇa*, *Vīrya*, *Vipāka* and *Karma* has not been lost sight of, though some of them appear to be abstract and subjective in the absence of established experimental methods to quantify them.

The Legal Notices and General Notices have been given for guidance of the analysts, the Pharmaceutical suppliers and manufactures and the research workers engaged in this field. Details about the apparatus, reagents and solutions, tests, methods of preparation of specimens for microscopic examinations have been given in the Appendices.

The Committee hopes that with the publication of Ayurvedic Pharmacopoeia of India Part I, Vol. VII comprising of 21 single drugs of mineral, metal origin, as per the format and procedure laid down, the different research units under Deptt. of AYUSH under the Ministry of Health and Family Welfare and the other involved laboratories would plan their research enquiries such that the output of work would be accelerated.

The Committee urges the Government of India to recommend the adoption of these monographs for the purposes of identity, purity and strength of drugs for use in their Government, Semi-Government and Government aided institutions and voluntary public organizations. The Ayurvedic Pharmacopoeia of India, Part-I, Vol. VII may also be notified by Government as a book of reference for implementation of the Drugs and Cosmetics Act, 1940 all over India as Ayurvedic Pharmacopoeia of India Part-I, Vol. I, II, III, IV and V is already included in the First Schedule of Drugs and Cosmetics Act 1940.

This volume is specific in nature consisting of monographs on raw materials of mineral and metals used in the mineral, metallic and herbo-mineral /metallic preparations.

Prof. S.S.Handa
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Member Secretary

ACKNOWLEDGMENT

The Ayurvedic Pharmacopoeia committee records and duly appreciates the contributions made by the project officers and scientific staff of the participating institutions associated with the APC project works for developing quality standards of Minerals and Metals.

The committee expresses gratitude of Ms. Anita Das, Secretary, and Shri Shiv Basant, Joint Secretary, Department of AYUSH for providing constant support for completion of this work and its further continuation and also sincerely thanks to Dr. M.M. Padhi, Deputy Director [Tech.]; Shri. Vasantha Kumar, Asst. Director [Chem.] Dr. Pramila Pant, Research Officer [Chem.], Dr. M.N. Rangne, Dr. Chhote Lal, Dr. AKS Bhadoria and Dr. Bishnupriya Dhar, Research Officer [Phar], Dr. Nikhil Jirankalgikar S.R.F. (Ayu.), Dr. Rajesh Singh S.R.F. [Ayu.], Dr. Sandhya Rani S.R.F. [Ayu.], Mr. Chinmay Rath S.R.F. [Bot.] for their constant efforts in bringing out this volume. Thanks to Mr. Ashish Kumar, Ms. Meenakshi Thakur, Ms. Deepti Anand D.E.O., who took pains in typing and arranging all the technical data into a final shape.

INTRODUCTION

General

The Ayurvedic system of medicine is prevalent in India since the Vedic period and as early as the dawn of human civilization. Though Ayurveda has undergone many changes in the course of its long history, it still remains the mainstay of medical relief to a large section of population of the nation. Due to urbanization and dwindling of forests, the Vaidya by and large is no longer a self contained unit collecting and preparing his own medicines as before. He has now to depend on the newly developed agencies like one collecting and supplying the crude drugs and the other undertaking mass production of medicines in the Ayurvedic Pharmaceutical units run on commercial scale.

2. In view of the new trend in Ayurvedic Pharmaceutical field, Government of India considered it expedient to utilize the existing Drug and Cosmetics Act 1940, to also control to a limited measure the Ayurvedic, Siddha and Unani drugs by amending the Act.

3. The Act was accordingly amended in 1964, to ensure only a limited control over the production and sale of these medicines namely:-

- i. The manufacture should be carried under prescribed hygienic conditions, under supervision of a person having a prescribed qualification;
- ii. The raw materials used in the preparation of drugs should be genuine and properly identified; and
- iii. The formula or the true list of all the ingredients, contained in the drugs, should be displayed on the label of every container.

The present Ayurvedic Pharmacopoeia Committee (APC) was reconstituted or constituted under the Deptt. of AYUSH vide letter No.X-19011/6/94-APC (AYUSH) dated 9th March, 2005 consisting of following members.

- | | |
|---|--|
| 1. Ms. Savita Satakopan, M.Sc.
(Former Drug Analyst),
Government of Gujarat,
7/4, Padmam Flats, Seventh Street,
Nanganallur, Chennai – 600 061. | Chairperson
(9 th March 2005 to
22 nd June 2006) |
| 2. Prof. S.S. Handa, M. Pharma, Ph.D.,
(Former Director, RRL, Jammu), 522-A, Block 'C',
Sushant Lok, Phase-I,
Gurgaon, Haryana – 122 001. | Chairman
(23 rd June, 2006 to
onwards) |

OFFICIAL MEMBERS

- | | | |
|----|--|----------------------------------|
| 1. | Dr. S.K. Sharma, M.D. (Ayu.), Ph.D.
Advisor (Ayurveda),
Department of AYUSH,
Red Cross Society Building,
New Delhi – 110 001. | Vice-Chairman |
| 2. | Dr. G.S. Lavekar, AVP; Ph.D.
Director,
Central Council for Research in Ayurveda & Siddha,
61-65, Institutional Area,
D-Block, Janakpuri,
New Delhi – 110 058. | Member-Secretary
(Ex-officio) |
| 3. | Dr. D.R. Lohar, M.Sc.; Ph.D.
Director,
Pharmacopoeial Laboratory for Indian Medicine,
Central Govt. Offices Complex, Kamla Nehru Nagar,
Ghaziabad – 201 002. | Member (Ex-officio) |
| 4. | Managing Director,
Indian Medicines Pharmaceutical Corporation Ltd.,
Mohan, Via – Ram Nagar,
Distt.- Almora, Uttranchal. | Member (Ex-officio) |
| 5. | Drugs Controller General (India),
Ministry of Health & Family Welfare,
Nirman Bhawan, New Delhi – 110 011. | Member (Ex-officio) |

NON-OFFICIAL MEMBERS

Phytochemistry & Chemistry Sub-Committee

- | | | |
|----|---|----------|
| 1. | Prof. V.K. Kapoor, M. Pharm., Ph.D.
(Former Dean and Chairman,
University Institute of Pharmaceutical Sciences,
Panjab University, Chandigarh)
1473, Pushpac Complex, 49B,
Chandigarh - 160 047. | Chairman |
| 2. | Prof. S.S. Handa, M. Pharm., Ph.D.,
(Former Director, RRL),
522-A, Block 'C', Sushant Lok, Phase-I,
Gurgaon, Haryana – 122 001. | Member |

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| 3. | Dr. P.D. Sethi, M. Pharm., Ph.D.,
(Former Director,
Central Indian Pharmacopoeial Laboratory)
B-140, Shivalik Enclave,
New Delhi – 110 017. | Member |
| | | |
| 4. | Shri J.K. Dhing, M.Sc., M. Tech.
Former Chief Manager (Exploration),
Hindustan Copper Ltd.,
SF-8, Gayatri Nagar,
Sector-5, Hiran Magri,
Udaipur – 313 002. (Rajasthan). | Member |

Pharmacognosy Sub-Committee

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|----|--|----------|
| 1. | Ms. S. Satakopan, M.Sc.
(Former Drug Analyst),
Government of Gujarat,
7/4, Padmam Flats, Seventh Street,
Nanganallur, Chennai – 600 061. | Chairman |
| | | |
| 2. | Dr. (Mrs.) Shanta Mehrotra, M.Sc., Ph.D.,
Emeritus Scientist,
National Botanical Research Institute,
Rana Pratap Marg, P.B. No.-436,
Lucknow – 226 001 (U.P.). | Member |
| | | |
| 3. | Dr. M.A. Iyengar, M. Pharma, Ph.D,
Prof. of Pharmacognosy (Retd.),
14, HIG, HUDCO, Manipal – 576 119. | Member |
| | | |
| 4. | Dr. J. Mohanasundaram, M.D.,
Former Professor of Pharmacology
& Deputy Director of Medical Education,
Chennai. | Member |

Formulary Sub-Committee

(Rasa Shastra / Bhaishajya Kalpana – Ayurvedic Pharmacy)

- | | | |
|----|---|----------|
| 1. | Prof. S.K. Dixit, A.B.M.S.; D. Ay. M; Ph.D.
(Former Head, Deptt. of Rasa Shastra, BHU),
B-3/402, Shivala, Varanasi - 221 005 (UP.). | Chairman |
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| 2. | Dr. B.L. Gaur, Ph.D.;
Vice-Chancellor,
Jodhpur Ayurvedic University, Jodhpur, Rajasthan. | Member |
| 3. | Prof. Siddhinandan Mishra, G.B.M.S.; Ph.D.
Pharmacy In-charge, SDM Ayurvedic College,
P.O. Kuthpady, Udupi – 574 118
(South Karnataka) | Member |
| 4. | Prof. Ved Vrat Sharma, H.P.A.
(Former Principal, DAV Ayurvedic College),
House No. 65, Sector-8, Panchkula, Haryana. | Member |
| 5. | Dr. P.K. Prajapati, M.D. (Ay.), Ph. D.,
Reader & Head, Deptt. of Ras Shastra,
IPGT & RA, Gujarat Ayurved University,
Jamnagar, Gujarat – 361 008. | Member |
| 6. | Dr. Narendra Bhatt, M.D. (Ay.),
Chief Executive Officer,
Zandu Pharmaceutical Works Ltd.,
70, Ghokhle Road (South), Dadar,
Mumbai – 400 025. | Member |
| 7. | Shri Ranjit Puranik,
General Manager,
Shree Dhootapapeshwar Ltd.,
135, Nanubhai Desai Road, Khetwadi,
Mumbai. | Member |

Ayurveda Sub-Committee

(Single Drugs of Plants, Minerals, Metals, Animal origin)

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|----|--|----------|
| 1. | Prof. V.K. Joshi, M.D. (Ay.), Ph.D.
Deptt. Dravyaguna,
Institute of Medical Sciences,
Banaras Hindu University (BHU),
Varanasi – 221 005 (U.P.). | Chairman |
| 2. | Prof. K.C. Chuneekar, Ph.D.
(Former Reader, Deptt. of Dravyaguna, BHU),
18/7, Ratan Phatak,
Varanasi, (U.P.). | Member |

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|----|--|--------|
| 3. | Vaidya Devender Triguna, Ayurvedacharya,
“PADAM SHREE”,
143-Sarai Kale Khan,
Nizamuddin East, New Delhi. | Member |
| | | |
| 4. | Dr. M.R. Uniyal, M.D. (Ay.), Ph.D.
(Former Director, CRIA, CCRAS),
Director (Drugs), Maharishi Ayurved Products,
17/18, NOIDA Export Processing Zone,
NOIDA – 201 305. | Member |
| | | |
| 5. | Prof. V.V. Prasad,
Director,
Rashtriya Ayurveda Vidyapeeth,
Dhanvantri Bhawan,
Road No. 66, Punjabi Bagh (West),
New Delhi – 110 026. | Member |

1. The term of the Committee shall be for a period of 3 years from the date of its first meeting and the members shall hold office for that period.
2. The chairman of the APC shall have the powers to form sub-committees whenever required and to co-opt experts from outside for such sub-committees.
3. The Committee shall have the power to frame procedures of functioning.
4. The functions of the Committee shall be as follows:
 - i. To prepare a Ayurvedic Pharmacopoeia of India of single and compound drugs.
 - ii. To prescribe the working standards for compound Ayurvedic formulations including tests for identity, purity, strength and quality so as to ensure uniformity of the finished formulations.
 - iii. Keeping in view the time constraint, to identify such methods, procedures and plan of work as would enable to publish the formulary and standards of all commonly used drugs to be brought out in a phased manner.

- iv. To prepare remaining parts of the official formulary of compound preparations from the classical texts including standardized composition of reputed institution.
- v. To develop and standardize methods of preparations, dosage form toxicity profile etc.
- vi. To develop Quality standards, safety, efficacy profile of Intermediates like extracts of Ayurvedic raw drugs.
- vii. To develop the Quality standards, safety, efficacy profile of different parts of the plants; as well as to inclusion of new plants as Ayurvedic drugs.
- viii. Any other matter relating to the Quality standards, shelf life, identification, new formulations etc.

5. The following are the targets focus of the Committee:

- i. To evolve standards of single drugs mentioned in the Ayurvedic Formularies of India.
- ii. To evolve standards for compound formulations mentioned in the Ayurvedic Formularies of India & other Ayurvedic formulations of National Priority.
- iii. To prepare drafts Standard Operation Procedure of Manufacturing Process (SOP) of Ayurvedic Formularies of India from the classical texts and other authentic sources.

SPECIAL INTRODUCTION TO VOLUME – VII (Minerals/Metals/Ores)

Preamble

The materia medica of the Indian Traditional Systems of Medicine is comprehensive in its resources from nature. Apart from a major share from medicinal plants, both animal products and geochemicals are in trade as well as in use by practitioners. The Formularies till now published by the Ministry of Health and Family Welfare, Govt. of India, lists about 65 substances of Minerals/Metals/Ores as raw materials for use either as single drugs or added to compound formulations. Such a list was prepared from classical medical literature in Āyurveda, by eminent vaidyas and practicing Āyurvedic pharmacists who were members of the earlier Āyurvedic Pharmacopoeia Committees in the seventies of last century. The list was finalized after extensive tours, on-the-spot examinations and consultations with practitioners and user-pharmacies throughout the country. They also, for the first time, equated the recorded names of single drug in Samskṛt literature, with its modern scientific nomenclature, with an eye to the future task of evolving quality standards for such raw drugs.

Methodology

The single drug list mentioned above formed the basis for present work. A general format using appropriate geological descriptive titles was drafted by the APC. The format specified the inputs required from the collaborating laboratories under various heads, so that a general description, analytical parameters for identification, their elemental composition, methods of tests and assays and Āyurvedic uses etc., would be available for each of the drugs selected. The format was sent along with a preliminary note to the invitees of a Special Committee of Experts, constituted by the Ministry under the APC. The experts were from Wadia Institute of Himalaya Geology, Dehradun, and also from Āyurvedic Research Institutes and Universities like Banaras Hindu University (BHU), Varanasi and Gujarat Āyurved University (GAU), Jamnagar. An Annexure to this introduction gives the details of the sittings and decisions of this committee.

As a sequel to the recommendation of this committee, further work was initiated by allotting a set of 47 Minerals/Metals/Ores to the National Institute of Āyurveda (N.I.A.), Jaipur under the Director as the Principal Investigator and Shri J.K. Dhing, Former Chief Manager (Exploration), Hindustan Copper Ltd., Khetri Nagar and Dr. V.N. Rao, Associate Professor, N.I.A., Jaipur as the Co-Investigators. Using both authentic and marketed samples, analytical work was executed at the laboratories of the Indian Bureau of Mines (IBM), Ajmer and Geological Survey of India (GSI), Jaipur, with Shri Dhing as the Co-ordinator. This volume is based on the results obtained from the above collaborating laboratories and on other inputs from Shri Dhing, Miss Satakopan and the Āyurvedic experts of the APC. It recommends specifications and standards for 21 raw drugs and includes other relevant details.

Structure of this Volume

A chapter on General Notices explains the rules and mechanisms that should be followed by analysts while applying the standards and tests in their work. There are various Appendices, detailing the methods of tests and assays, the reagents in use, and the equipments and apparatuses necessary. A special feature is a Glossary, to explain the geological terms used in describing the physical properties of the drugs. This is given to help analysts of pharmaceutical manufacturers and the regulatory bodies who may not be familiar with the terminology used in identification of Minerals/Metals/Ores. On the āyurvedic part of each monograph, the 'Śodhana', represents the purity measures as mandatory. Unlike plant or animal products, there is no prior preparation of a mineral drug for the market, by any physical or chemical means. Purity for an āyurvedic Mineral/Metal/Ore does not imply the same as it does for other drugs and does not deal with extraneous or introduced matter. While identity and strength are dealt with by physical and chemical modern tests, the purity requirement of a pharmacopoeial mineral/metal based drug is determined by Āyurvedic process described as 'Śodhana'. Original ślokas dealing with 'Śodhana' are included in Appendix-5. Hopefully, this would curtail the shortcuts now believed to be in use, by side-stepping the tedious 'Śodhana' required and also discourages adverse comments that undesired toxic remains are present in such Āyurvedic preparations.

A preface (प्रस्तावना) written in Hindi by Dr. B.L. Gaur, currently Vice-Chancellor, Rajasthan Āyurved University, Jodhpur (Rajasthan), and a member of the APC, is another feature of departure from routine editorial structure followed for pharmacopoeia. It is necessary to explain the logic behind the use of substances known to be toxic, in medicines for human use, place it in a correct perspective from the Ayurvedic point of view and counter any misinterpretation. The inclusion of geochemicals in the treatment of human diseases by traditional method in Ayurveda should be justifiable. Hence, this special effort.

Scope and Limitations

A pharmacopoeia emerges out of the common interests of stake holders. Its ultimate purpose is to aid the implementation of the requirements under a legislation, which ensures supply of quality drugs to a nation, and also monitors the activities of those responsible for this. The core of objectives for a pharmacopoeia lies in the prescription of quality standards. Such standards should be scientifically sound, technologically attainable (by a small, medium and large scale industry equally), economically viable (for both industry and the common man in relation to the marketed product) and finally, culturally and conceptually compatible to the tenets of the Ayurvedic systems of treatment. These are basic to a well worked out pharmacopoeia for traditional medicines.

Constraints and compromises are inevitable in a pharmacopoeia for traditional medicines, considering that empirical wisdom, accumulated over a few thousand years by a highly evolved society in ancient India, is sought to be shackled in a framework of

requirements for the 21st century, in an effort to 'modernize' and keep up a global participation. In addition, this is attempted in a scientific environment of huge knowledge gaps, owing to absence of research by modern scientists. Although the metal/mineral drugs have been in clinical practice in Ayurveda and in trade since a long time, their role in pharmacology and therapeutics have not been elucidated. The unfortunate effect of this can be seen in the monographs, where assay limits have been set for possible active chemical entities on theoretical grounds and not on clinical data. It has not been possible to decide definitely, which major element or minor element or trace elements present in such a complex material (an ore) would contribute to the recorded curative properties of the drug using that mineral/metal, and, on that evidence, set a range of upper and lower limit. Hopefully, future research may throw light on such aspects and help improve or rationalize the standards.

The sophisticated analytical methods that are invariably carried out using costly imported machinery, is a deterrent to their introduction in the Ayurvedic pharmacopoeia. India still lives in its villages and 75 percent of the rural and remote households still depend on traditional medicines. There is no use in having methods that ensure excellent analytical performance of a drug, but the drug itself is inaccessible to the one who needs it, because of the cost factor. Keeping this aspect in view, the APC has strived for a compromise, using much simpler methods and prescribing standards that are weighted rather heavily on parameters that ensure correct identity, established purity at the expense of an accurate estimation of strength. This is also in keeping with the belief that quality medicines in Āyurveda for public use can well be promoted by using a correctly identified and purified raw material and following GMPs prescribed both by Ayurveda and modern pharmaceuticals, even if its mode is unknown.

In the above paragraphs, only a few important impediments to the development of quality standards for Ayurvedic medicines have been outlined so as to keep them at par with accepted norms for modern medicines. There are many more grey areas to be tackled, especially in compound formulations using geochemicals like Bhasmas and Rasayogas, but with these words, we offer this volume for public use and welcome comments and criticisms to enhance its value in future revisions.

Members of APC

MINUTES OF THE 1ST MEETING HELD ON 12TH & 13TH JUNE, 2000 WITH THE EXPERTS OF 'RASA SHASTRA', GEOLOGY' & OTHER SCIENTISTS TO CLARIFY ISSUES RELATING TO THE MINERALS & METAL SINGLE DRUG USED IN AYURVEDIC FORMULATIONS.

A meeting was called for by the Adviser (Ayurveda), Ministry of Health & Family Welfare, on the 12th and 13th of June 2000, to discuss the format, and identity of the mineral drugs included in the Ayurvedic Formulary of India, Part-I and II. Since the advice of experts in the subjects Geology and Mineralogy would help the scientist and the physician members of the Ayurvedic Pharmacopoeia Committee, to work on the monographs for these drugs, some geologists from well known institutes were invited to participate. Request was also made for actual samples to be brought to the meeting so that the experts could give their opinion on them. Several of the Vaidyas had brought whatever samples they had, for reference at the meeting. The following experts who had been invited were present:

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| 1. | Ms. S. Satakopan,
Member-APC
Chairman (In the absence of Adviser) | Chennai |
| 2. | Prof. S.S. Handa,
Ex-Director
Regional Research Laboratory, | New Delhi |
| 3. | Prof. M. Joshi,
Professor of Geology,
Banaras Hindu University | Varanasi |
| 4. | Prof. Ved Vrat Sharma,
Retd. Professor of Ras Shastra | Jalndhar |
| 5. | Vd. Nanak Chand Sharma
Director,
Kaya Maya Pharmacy | New Delhi |
| 6. | Dr. C.B. Jha
Reader,
Deptt. of Ras Shastra
Banaras Hindu University | Varanasi |
| 7. | Dr. K.K. Sharma
Wadia Institute of Himalayan Geology, | Dehradun |

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| 8. | Dr. N.S. Virdi
Director
Wadia Institute of Himalayan Geology | Dehradun |
| 9. | Dr. Y.B. Tripathi
Reader,
Deptt of Medicinal Chemistry,
Institution of Medical Sciences,
Banaras Hindu University | Varanasi |
| 10. | Dr. R.U. Ahmed,
Director, PLIM | Ghaziabad |
| 11. | Dr. Rajeev Kumar,
Senior Scientific Officer, PLIM | Ghaziabad |
| 12. | Dr. P. C. Srivastava
Senior Scientific Officer, PLIM | Ghaziabad |
| 13. | Dr. N.N. Pandey,
Chemist
Drug Testing Laboratory | Haridwar |
| 14. | Dr. M.L. Sharma,
Deputy Adviser (AY.) | Deptt. of ISM & H |
| 15. | Dr. Aliya Aman,
Deputy Adviser (Unani) | Deptt. of ISM & H |
| 16. | Dr. J. Pandey,
Asstt. Adviser (Ayur) | Deptt. of ISM & H |
| 17. | Dr. D.C. Katoch,
Asstt. Adviser (Ayur) | Deptt. of ISM & H |
| 18. | Dr. Chhote Lal,
S.T. A. (Ayur) | Deptt. of ISM & H |
| 19. | Dr. A.K.S. Bhadoria,
Research Asstt. (Ayur) | Deptt. of ISM & H |

Following experts could not attend the meeting

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|----|----------------------------|-----------|
| 1. | Dr. I Sanjeev Rao | Hyderabad |
| 2. | Dr. (Mrs.) A. S. Paranjape | Varanasi |
| 3. | Prof. R.K. Lal | Varanasi |
| 4. | Dr. Balendu Prakash | Dehradun |

A background note and a list of minerals in use by the practitioners in Ayurveda, Siddha and Unani had earlier been distributed. A draft format for preparing the monographs under suitable parameters was also distributed at the meeting, so that the geologist present at the meeting may suggest additions or alterations, and finalise a format for drafting monographs.

At the beginning, the chairman explained the work to be done, and the help desired from the experts in Geology, on the basis of discussions with the Vaidyas across the table, and their observations on the clinical use of the minerals. After some general discussion, the following business was conducted.

1. The geological experts found the draft format for preparing monographs satisfactory for its purpose and agreed that it gave sufficient characteristics for identity of the minerals and metals.
2. Each item in the list supplied already, with a note on each, giving the available current information was then taken up and decisions taken regarding their identity and scientific names.
3. Since the latest information on the minerals and metals would be available with geologists, they were requested to kindly help the APC by furnishing more details.
 - a) Title (this would be the same as that appearing in the list)
 - b) Broad classification (Details already given in the format)

प्रस्तावना

आयुर्वेद का उपदेश एवं तदनुरूप प्रयोग मनुष्य मात्र के हित के लिये हुआ है। आयुर्वेद के मूलभूत सिद्धान्तों में पञ्चमहाभूत की अवधारणा एक महत्त्वपूर्ण सिद्धान्त हैं। शरीर को पाञ्चभौतिक माना गया है तथा इस शरीर का शीर्णन शरीर के स्वरूप के आधार पर होने के साथ साथ देश-काल-बल-वय-प्रकृति-आहार आदि अनेक कारणों से प्रभावित होता है। जिसके कारण एक ही व्यक्ति में भिन्न-भिन्न समय में भिन्न-भिन्न परिमाण में न्यून या अधिक शीर्णन होता है अथवा एक ही कारण से भिन्न-भिन्न परिमाण में न्यून या अधिक शीर्णन होता है। भिन्न-भिन्न व्यक्तियों में भिन्न-भिन्न परिमाण में यह शीर्णन होता है।

प्राचीन आचार्यों ने गहन अध्ययन एवं व्यवस्थित अनुसन्धानों के सुनियत-क्रम को प्रयुक्त कर सूक्ष्मेक्षण पूर्वक जो तथ्य प्रकाशित किये वे आश्चर्यजनक हैं। ये तथ्य दो प्रकार से प्रस्तुत हैं - स्पष्टतः नामनिर्देशपरक एवं संकेतपरक। उदाहरण के रूप में शरीर में जो शीर्णन या क्षय होता है उसका नामतः निर्देश है। मांसक्षय में मांस प्रयोग एवं उदकक्षय में पेयस्वरूपक सन्तर्पण प्रयोग यह नामतः निर्देश का उदाहरण है। दूसरा निर्देश संकेतपरक है, जिसमें रक्तक्षय में लौह प्रयोग अथवा श्वित्र में ताम्र-प्रयोग। इनका प्रयोग शरीर में करने से क्रमशः रक्ताणु का निर्माण एवं भ्राजक पित्त के कार्य का व्यवस्थित रूप से सम्पादन होता है जिससे रक्तक्षय का अपनयन एवं त्वचा के द्वारा अपने स्वाभाविक वर्ण को प्राप्त करना है।

यह इस बात का संकेत है कि वनस्पतियों में जो पञ्चमहाभूतों के प्रतिनिधि द्रव्य हैं वे शरीरस्थ तत्त्वों को पुष्ट करते हैं। साथ ही शरीर में खनिज एवं धातुओं के प्रतिनिधि द्रव्य भी होते हैं जो लौह, ताम्र आदि के समस्वरूप हैं। इनकी भी पूर्ति वनस्पतियों से हो जाती है, लेकिन इन धातुस्वरूपक तत्त्वों की क्षीणता यदि अधिक है तो तत्परक वनस्पतियाँ इसकी पूर्ति के लिये पर्याप्त नहीं होती, अतः उन-उन खनिजों या धातुओं का अथवा अयस्कों का प्रयोग आवश्यक माना जा कर उनका विधिपूर्वक प्रयोग भी आचार्यों ने निर्धारित किया।

इससे यह स्पष्ट होता है कि आचार्यों के द्वारा यह अनुसन्धान किया जा चुका था कि शरीर में कौन से तत्त्व की कमी होने या अधिकता होने से कौन से लक्षण उत्पन्न होते हैं तथा उन्हें दूर करने के लिये कौन से द्रव्य (वनस्पति, खनिज एवं धातु आदि) उपयुक्त हैं।

वर्तमान काल में विभिन्न विषयों के विख्यात विशेषज्ञों के द्वारा एक स्वर में आवाज उठाई जा रही है कि आयुर्वेदीय रस-भस्मों शरीर के लिये घातक हैं एवं हानिकारक हैं। इसमें पाश्चात्य देशों के वैज्ञानिक प्रमुख हैं। ये बातें वे यों ही नहीं कह रहे, अपितु नवीनतम अनुसन्धानों के आधार पर कह रहे हैं, अतः उन्हें सहसा झुँटलाया या समझाया नहीं जा सकता।

लेकिन यह भी जान लेना चाहिये कि उनके ये अनुसन्धान-परिणाम एकतः सही होते हुये भी एकान्ततः सही नहीं हैं। लेकिन उन्हें यह बात निश्चित मापदण्डों एवं विधि-विहित-प्रक्रियाओं के द्वारा ही समझायी जा सकती है। जिसके लिये भारत-सरकार के आयुष-विभाग ने बीडा उठाया है तथा आयुर्वेदीय औषध-निर्माण की सम्पूर्ण प्रक्रियाओं को आधुनिक मापदण्डों पर परिमापित कर सम्पूर्ण विज्ञान-विशेषज्ञों के सामने रखने का स्तुत्य प्रयास किया है।

इस सन्दर्भ में सब से पहले एक बात समझ लेना आवश्यक है कि ये खनिज एवं धातु आदि शरीर के लिये तभी हितकर हैं जबकि इनका विधिविहित-प्रयोग हो, अन्यथा वे अहितकर ही होते हैं। इनके विधिविहित-प्रयोग को ४ स्तरों में विभक्त किया जा सकता है-

- १ खनिज, धातु आदि के उत्तम स्वरूप का चयन
- २ खनिज आदि का समुचित शोधन
- ३ इनका समुचित मारण (भस्म-निर्माण)
- ४ इनका नियत अनुपान एवं समुचित पथ्य के साथ प्रयोग

जो काम आयुर्वेदिक फार्मोकोपिया कमेटी (APC) कर रही है, यह अब नया है, यह कतई नहीं समझना चाहिये। उपर्युक्त चारों कार्य (या स्तर) तो सदियों से होते आये हैं। लेकिन इतना अवश्य है कि APC इन्हें नवीनतम मापदण्डों के रूप में प्रस्तुत कर रही है। पहले आधार द्रव्य (Raw Drugs) का चयन शोधन, मारण एवं प्रयोग ये चारों स्तर एक ही व्यक्ति, संस्था या समूह के द्वारा सम्पादित किये जाते थे अतः द्रव्यप्राप्ति में संशय, शोधन में अभाव, निर्माण में समग्र विधि के प्रयोग का अभाव या त्रुटि एवं प्रयोग में सावहितचित्तता का अभाव नहीं होता था जो वर्तमान में हो रहा है। द्रव्य का चयन या प्राप्ति अन्य संस्था या समूह करवाता है, शोधन एवं मारण अन्य के द्वारा सम्पादित होता है तथा प्रयोग किसी अन्य के द्वारा होता है। अतः नवीन सन्दर्भ में परीक्षित मापदण्डों का सुनिश्चितीकरण एवं प्रचारण परमावश्यक है।

औषध निर्माण में जितने भी द्रव्य काम में लिये जाते हैं उनमें १५ प्रतिशत द्रव्य खनिज, धातु और अयस्क हैं। एक महत्त्वपूर्ण उल्लेखनीय तथ्य यह भी है कि शास्त्रों में उल्लिखित शास्त्रीय योगों में लगभग ५३ प्रतिशत ऐसे योग हैं जिनमें खनिज या धातु या अयस्क भी हैं। अतः यह - आवश्यक है कि

- (क) द्रव्य के परीक्षण की नियत प्रक्रिया हो जो भौतिक और रासायनिक परीक्षण के मापदण्ड स्वरूप में हो।
- (ख) इन में पाये जाने वाले घटक तत्त्वों की मात्रा सुनिश्चित हो।
- (ग) प्रमुख कार्यकारी तत्त्व के प्रतिशत की सीमा तय हो।
- (घ) पहचान के सुनिश्चित चिह्न होने चाहिये।
- (ङ) ये खनिज आदि उपयोगी स्वरूप में प्राप्त हों।
- (च) इनका शोधन एवं मारण विधिपरक हो।

(छ) इनकी एक बार में प्रयुक्त की जाने वाली अधिकतम मात्रा, न्यूनतम मात्रा एवं पूर्णतः प्रयुज्यमान मात्रा सुनिश्चित हो।

इन सब बातों को ध्यान में रखते हुये जो प्रक्रिया अपनायी गई, उसके आधार पर सर्वप्रथम २१ द्रव्यों का परिचय तैयार कर प्रकाशित किया जा रहा है, जिस में प्रमुख विशेषतायें ये हैं-

- (क) आयुर्वेद की संहिताओं और निघण्टुओं के आधार पर इनके वर्ण, स्वरूप, भारस्थिति एवं गन्धादि से सम्बन्धित वर्णन
- (ख) इन ग्रन्थों के आधार पर ही रस, गुण, वीर्य, विपाक और प्रभाव का उल्लेख
- (ग) अग्नि या अन्य उपाय, यदि शास्त्र में उल्लिखित हैं तो उनके आधार पर किये जाने वाले रासायनिक परीक्षणों का उल्लेख।
- (घ) आधुनिक अनुसन्धानों के आधार पर सुनिश्चित वर्ण-स्वरूप आदि के प्रकाशित तथ्यों का उल्लेख।
- (ङ) प्रयोगशालीय प्रामाणिक परीक्षणों का उल्लेख
- (च) मोनोग्राफ निर्माण
इन सब विशेषताओं के आधार पर संकलित, रचित, उल्लिखित एवं सम्पादित अंशों से युक्त यह प्रथम प्रकाशन अत्यन्त उपयोगी रहेगा तथा इसके निम्नलिखित परिणाम आने सुनिश्चित हैं, यथा-
- (क) उपयोगी उचित द्रव्यों की समुचित पहचान एवं सहज उपलब्धि।
- (ख) उत्तम द्रव्यों की उपलब्धि की प्रक्रिया के निर्धारण में शासकीय सहभागिता।
- (ग) द्रव्यों की सन्दिग्धता की परिसमाप्ति
- (घ) आधुनिक विज्ञान के सन्दर्भ में मापदण्ड होने से सभी को स्वीकार्य।
- (ङ) अन्य देशों में प्रयोग-प्रक्रिया हेतु समुचित आधार का निर्माण।
- (च) द्रव्य की रासायनिक-प्रक्रिया का आधुनिक सन्दर्भ में विश्लेषणपरक पूर्ण ज्ञान होने से इनके लिये शास्त्रों में उल्लिखित शोधन-प्रक्रिया को अपनाने में औषध-निर्माताओं को प्रेरणा मिलेगी।
- (छ) इस सन्दर्भ में आगे अनुसन्धान के मार्ग खुलेंगे और अनुसन्धानकर्ताओं को प्रेरणा मिलेगी।
- (ज) जो लोग इन से निर्मित औषधियों को घातक बताते हैं तथा आलोचना करते हैं उनको समुचित जवाब मिलेगा।
- (झ) सब से बड़ा लाभ यह है कि बाजार में अल्पगुण, अल्पप्रभावी, अनुपयोगी द्रव्यों के स्थान पर गुणवान्, प्रभावी एवं उपयोगी द्रव्य मिलने लगेंगे।
- (ञ) Drugs and cosmetics act 1940 के अनुरूप उपयुक्त मापदण्डों के अनुरूप औषध-निर्माण हेतु बाध्य किया जा सकता है तथा इसको समुचित रूप से लागू किया जा सकता है।

वैद्य बनवारी लाल गौड
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CONTRIBUTING LABORATORIES & INSTITUTIONS

Various tests, studies and analyses, conducted for raw drugs by the following institutions/laboratories, are sincerely acknowledged:

1. National Institute of Ayurveda, Jaipur (Rajasthan) India.
2. Geological Survey of India (Western Region), Jaipur (Rajasthan), India.
3. Regional Ore Dressing Laboratory, Indian Bureau of Mines, Ajmer (Rajasthan), India.
4. Regional Ore Dressing Laboratory, Indian Bureau of Mines, Nagpur (Maharashtra), India.

MONOGRAPHS

ABHRAKA

(Biotite Mica)

1. **Definition** : *Abhraka* is Biotite mica, a ferro-magnesium silicate $K(Mg Fe)_3 X(Si_3AlO_{11}) X(OH)_2$. It is a black variety of mica group of minerals.

2. **Synonyms:**

2.1 **Saṁskṛta** : *Ghana, Vyoma, Abhra, Niścandra, Vyomaka, Vajra, Vajrābhra, Kṛṣṇābhra*

2.2 **Names in other Languages:**

Bangali	-	Abhraka
English	-	Mica
Gujarati	-	Abhraka
Hindi	-	Abhrak, Abarak
Kannada	-	Abhraka
Malayalam	-	Abrakam
Marathi	-	Abhraka
Tamil	-	Abragam, Karuppu Appirakam (S.F.I.)
Telugu	-	Abbarakam
Urdu	-	Abrak Siyah (N.F.U.M.)

3. **Broad Classification:** A Phyllo-Silicate

4. **Origin and occurrence:** *Abhraka* occurs in igneous rocks in pure form as well as in metamorphic rocks as schists and gneisses. It occurs in ore form in pegmatites but pure mineral in sheet-form can be made available through sorting in pegmatite bodies.

It is found in all igneous terrains of the earth's crust. In India, it occurs mostly in the mica belts of Rajasthan, Andhra Pradesh and Jharkhand. The main deposits in these states occur at Ajmer, Bhilwara, Tonk and Pali in Rajasthan, Kalichedu, Thalpur and Gudur in Andhra Pradesh, Koderma and Giridih in Jharkhand. Other known occurrences are in the states of Tamil Nadu, Karnataka, Kerala and West Bengal.

5. **Physical properties:** (Definition/Explanation of technical terms and Methods of Determination as given in Appendix –1).

Nature	:	Platy (separable in thin layers)
Colour	:	Greenish black
Streak	:	Greenish black
Cleavage	:	Perfect
Fracture	:	Uneven
Lustre	:	Splendent
Tenacity	:	Flexible

Transparency	:	Translucent
Hardness	:	2.5 to 3
Sp. Gr.	:	2.6 to 3

6. **Optical Properties:** Anisotropic, Biaxial Negative, small 2V and strong birefringence. Refractive Index: η_{α} 1.565-1.625; η_{β} 1.605- 1.696; η_{γ} 1.605-1.696 (Appendix-2).
7. **Chemical Properties:**
 - 7.1 **Effect of Heat:** Hold a piece of *Abhraka* by forceps and heat it over a burner flame in its outer zone (about 1000⁰). It swells almost double in volume. Colour changes from black to silver moon while, water is released.
 - 7.2 **Solubility:** Take about 1 g finely powdered (150 mesh) sample of *Abhraka* in 250 ml beaker. Add 50 ml *sulphuric acid*. Stir the solution. It decomposes leaving skeleton of silica (distinction from other micas which are not affected by sulphuric acid).
 - 7.3 **Assay:** Should contain not less than 50% silica (SiO₂) when analysed by gravimetric method (Appendix-3.1.3).
 - 7.4 **Heavy metals and Arsenic:** Should not contain more than the stated limits for the following: - Lead = 45 ppm, Arsenic = 3 ppm, and Cadmium =2 ppm (Appendix-3.2).
 - 7.5 **Other Elements:** May contain the following within $\pm$ 20% of the stated limits:- Iron = 6%, Aluminium = 5%, Magnesium = 9% and Potassium = 5% (Appendix-3.1 & 3.2).
8. **Śodhana:** Shall not be used in formulation without subjecting it to *śodhana*.
9. *Abhraka* is always used in the form of *bhasma*, the therapeutic uses, dose and other details of which are given in the monograph of *bhasma*.

AKĪKA (Agate)

1. **Definition:** *Akīka* is a silica mineral (SiO_2). It is the banded form of Chalcedony.

2. **Synonyms:**

2.1 **Saṃskṛta :** *Akīka*

2.2 **Names in other Languages:**

English	-	Quartz, Chacedony
Hindi	-	Akīka
Punjabi	-	Mank, Akīka
Urdu	-	Aqeeq (N.F.U.M.)

3. **Broad Classification:** Crypto crystalline Silica Mineral

4. **Origin and occurrence:** *Akīka* occurs generally in pure form. It occurs all over the earth's crust in igneous as well as metamorphic rocks. Wherever cavities are developed, silica is deposited and the material becomes *Akīka*. Banding in *Akīka* is due to interrupted deposition of silica in cavities. It is a very common semi-precious ornamental stone.

Akīka occurs mainly as fillings in the voids in the Deccan Trap rocks. The most important occurrence of *Akīka* in India is Rajpipla area and further west between the mouths of river Tapti and Narmada in Bharuch district, Gujarat. Other occurrences of economic importance are known at Amaravati, Aurangabad, Buldhana, Chandrapur, Jalna, Nasik and Pune in Maharashtra, beds of Krishna and Godavari rivers in Andhra Pradesh, Rajmahal and Sahebganj in Bihar, Dhar and Mandsaur in Madhya Pradesh and Jamnagar, Kutch and Surat in Gujarat.

5. **Physical Properties:** (Definition/Explanation of technical terms and Methods of Determination as given in Appendix-1).

Nature	:	Banded form
Colour	:	White
Streak	:	White
Cleavage	:	Not present
Fracture	:	Conchoidal
Lustre	:	Waxy
Tenacity	:	Brittle
Transparency	:	Sub- translucent
Hardness	:	6 to 7
Sp. Gr.	:	2.5 to 2.65
Fluorescence	:	Remains dark when observed after irradiation with near UV light of 365 to 400 nm

6. **Optical Properties:** *Akīka* is uniaxial, positive, showing birefringence between crossed nicols, with refractive indices between 1.530 and 1.555 with η_w 1.544 and η_e 1.553 (Appendix-2).
7. **Chemical Properties:**
- 7.1 **Reaction with acids:** Take about 5 g finely powdered (150 mesh) sample of *Akīka* in a test tube. Add 10 ml dilute *hydrofluoric acid*. It dissolves completely in *hydrofluoric acid*. (Care should be taken in handling *hydrofluoric acid*).
- No other acid has any reaction or effect on *Akīka*.
- 7.2 **Assay:** Should contain not less than 95% Silica (SiO₂) when analysed by gravimetric method (Appendix-3.1.3).
- 7.3 **Heavy metals and Arsenic:** Should not contain more than the stated limits for the following:- Arsenic = 190 ppm, and Cadmium = 1.6 ppm (Appendix-3.2).
8. **Diagnostic property:** Bands of *Akīka* are typically parallel to each other.
9. **Śodhana:** Shall not be used in formulations without subjecting it to śodhana.
- 9.1 **Śodhana:** [Ref. Rasatantrasāra Siddha Prayoga Saṅgraha, Part-1, page 73]

- | | | | |
|-----|----------------|---|--------|
| i) | <i>Akīka</i> | : | 1 part |
| ii) | Gulāba Jala | | |
| | or | | |
| | Arka Vedamuśka | | |
| | or | | |
| | Go-dugdha | : | Q.S |

Method:

Heat *Akīka* till it becomes red-hot and dip in Gulāba Jala or Arka Vedamuśka or Go-dugdha for 21 times.

10. *Akīka* is used in the form of *piṣṭī* or *bhasma*, the details of which are given in the monograph of *piṣṭī* or *bhasma*.

GAIRIKA (Red Ochre)

1. **Definition:** *Gairika* is Red Ochre, an oxide of Iron (Fe_2O_3). This mostly earthy variety of hematite mineral is also known as Reddle.

2. **Synonyms:**

2.1 **Saṃskṛta** : *Kāṣāyakkal, Kāvi, Svarṇagairika*

2.2 **Names in other Languages:**

Bangali	-	Girimāṭī
English	-	Ochre, Reddle
Gujarati	-	Geru, Sonāgeru
Hindi	-	Geru, Gerumitti
Kannada	-	Hojātha, Jajoo, Kaavi, Kemmannu
Malayalam	-	Kavimannu
Marathi	-	Gerū, Sonakāva
Punjabi	-	Geri
Tamil	-	Seemaikkaavikkallu, Kāvikkal (S.F.I.)
Telugu	-	Kavirāyī, Kaavi
Urdu	-	Geru (Teen-e-Rumi) (N.F.U.M.)

3. **Broad Classification:** Oxide

4. **Origin and occurrence:** Basically a hematite mineral, *Gairika* is a natural mineral pigment found with other iron-titanium oxide minerals in igneous and metamorphic rocks as accessory mineral. *Gairika* is associated with magnetite. It sometimes contains minor amount of titanium and magnesium. *Gairika* occurs as an alteration product of other iron minerals or by degradation of highly ferruginous rocks in the form of weathered residual concentrations. It is generally found mixed with clay and other impurities.

Based on their colour, there are two types of ochres found in the country i.e. Red ochre and Yellow ochre. Anhydrous ironoxide is **red ochre** (*Gairika*) and hydrated iron oxide is **yellow ochre**.

In India, *Gairika* (Red ochre) is widely distributed. *Gairika* deposits are chiefly found in Rajpur, Banaskantha, Jamnagar and Kuchchh in Gujarat, Bellary and Bidar in Karnataka, Gwalior, Jabalpur, Satna, Kailashpur, Madhogarh and Mandla in Madhya Pradesh and Udaipur, Alwar, Bikaner, Chittorgarh and Sawai Madhopur in Rajasthan. Other known occurrences are in Andhra Pradesh and West Bengal.

5. **Physical properties:** (Definition/explanation of technical terms and methods of determination as given in Appendix –1).

Nature	:	Massive clayey
Colour	:	Reddish brown

Streak	:	Reddish brown
Fracture	:	Uneven
Lustre	:	Earthy
Tenacity	:	Brittle
Transparency	:	Opaque
Hardness	:	5.5 to 6.5 but much softer in earthy variety
Sp. Gr.	:	2.7

6. Chemical Properties:

6.1 Effect of Heat:

6.1.1 *Gairika* becomes magnetic on heating. Magnetism can be felt using a horse-shoe magnet (Appendix-3.3.3/1.9).

6.1.2 Does not easily fuse in a blow - pipe flame.

6.2 Solubility in Acid: Soluble in *hydrochloric acid*.

6.3 Assay:

Gairika should not contain less than 16% Fe or not less than 21% Fe₂O₃ when analysed by gravimetric method (Appendix-3.1.4).

6.4 Heavy metals and Arsenic: *Gairika* should not contain more than the stated limits for the following:- Lead = 6 ppm, Arsenic = 2 ppm and Cadmium = 2 ppm (Appendix-3.2).

6.5 Other elements: May contain the following within $\pm 20\%$ of the stated limits:- 1% Magnesium and 1% Titanium (Appendix-3.1 & 3.2).

7. Śodhana: Shall not be used in formulations without subjecting it to śodhana.

7.1 Śodhana: [Ref: Rasaratna Samuccaya 3/49]

- | | | |
|-------------------|---|-----------------|
| i) <i>Gairika</i> | : | 1 Part |
| ii) Go-dugdha | : | Q.S for Bhāvanā |

Method:

Prepare fine powder of *Gairika* and *Bhāvanā* of Go-dugdha should be given three times with sufficient quantity, dry and use for therapeutic purposes.

8. *Gairika* has the following attributes:

8.1 Properties and Actions:

Rasa	-	Madhura, Kaṣāya
Guṇa	-	Snigdha, Viśada
Vīrya	-	Śīta
Vipāka	-	Madhura

Vipāka	-	Madhura
Karma	-	Pitta-Nāśaka, Balya, Vraṇa Ropaṇa, Netrya, Kaphajit

8.2 Therapeutic Uses of śuddha *Gairika*: Netra roga (diseases of eyes); Raktapitta (bleeding disorder); hikkā (hiccup); vamaṇa (vomiting); viṣa vikāra (disorders due to poison); Rakta pradara (Menorrhagia or Metrorrhagia or both); kaṇḍū (itching); Jvara (fever); dāha (burning sensation); Udara roga (diseases of abdomen)

9. Dose: 250 - 500 mg of śuddha *Gairika*.

10. Important Formulations: Kuṅkumādi taila, Bhṛṅgarāja taila, Tutthādi lepa, Mahā Jvarāṅkuśa rasa, Laghu Sūtaśekhara rasa, Kāmadudhā rasa (Mauktika yukta)

GANDHAKA

(SULPHUR)

1. **Definition:** *Gandhaka* is sulphur (S), a non-metallic solid element.

2. **Synonyms:**

2.1 **Saṃskṛta** : *Bali, Daityendra, Gandha, Sugandhaka, Valī, Sugandhika*

2.2 **Names in other Languages:**

Assami	-	Kibrīt
Bangali	-	Gandhaka
English	-	Sulphur
Gujarati	-	Gandhaka
Hindi	-	Gandhaka
Kannada	-	Gandaga
Malayalam	-	Gandagam
Marathi	-	Gandhaka
Punjabi	-	Gandhaka
Tamil	-	Kandagam, Kantakam (S.F.I.)
Telugu	-	Gandhakam
Urdu	-	Kibreet (Gandhak) (N.F.U.M.)

3. **Broad Classification:** Native element

4. **Origin and occurrence:** Native *Gandhaka* occurs in the craters and crevices of extinct volcanoes where it has been deposited as a direct sublimation product from volcanic gases. It also occurs around thermal springs, in salt dome cap-rocks and in sedimentary sequences that contain sulphates along with organic materials like bituminous limestone. *Gandhaka* is frequently associated with gypsum and limestone. Native *Gandhaka*, which is contaminated with sand or clay, bitumen and such foreign matter, is purified by melting in oven or by distilling in closed vessels.

In India, the deposits of *Gandhaka* are very much limited. The only known occurrence is that of Tsokar Lake, Leh district in Jammu and Kashmir. There is no mining for *Gandhaka* in India. Elemental *Gandhaka*, however, is recovered commercially as a by-product from fertilizer plants at Panipat in Haryana, Naya Nangal and Bhatinda in Punjab and Oil Refinery at Mathura in Uttar Pradesh. There are huge deposits of elemental *Gandhaka* buried underground in certain parts of the world especially Poland, Mexico and USA.

5. **Physical properties:** (Definition/explanation of technical terms and methods of determination as given in Appendix-1).

Nature	:	Crystalline lumps
Colour	:	Sulphur yellow
Streak	:	Yellowish white
Cleavage	∴	Poor

Fracture	:	Conchoidal
Lustre	:	Resinous
Tenacity	:	Brittle
Transparency	:	Translucent
Hardness	:	1.5 to 2.5
Sp. Gr.	:	1.95 to 2.10

6. Chemical Properties:

6.1 Effect of Heat:

6.1.1 On burning a small quantity in a crucible, *Gandhaka* partially melts with evolution of brownish sulphur fumes.

6.1.2 *Gandhaka* melts at about 110° where as it burris at 270° in air with a bluish flame yielding sulphur-di-oxide (SO₂).

6.2 Solubility: Insoluble in water as well as any acid, but soluble in carbon-di-sulphide.

6.3 Assay: Should contain not less than 90% Sulphur, when analysed by gravimetric method (Appendix-3.1.8).

6.4 Heavy metals and Arsenic: Should not contain more than the stated limits for the following: Arsenic = 1 ppm and Cadmium = 2 ppm (Appendix-3.2).

7. Śodhana: Shall not be used in formulations without subjecting it to śodhana.

7.1 Śodhana: [Ref: Rasāmṛtam-2/3]

- | | | |
|------------------------------|---|--------|
| i) <i>Gandhaka</i> | : | 1 part |
| ii) <i>Go-dugdha</i> | | |
| or | | |
| <i>Bhṛṅgarāja rasa</i> (Pl.) | : | Q.S |

Method:

Take fine powder of *Gandhakā* in a ladle, add little amount of *ghṛta*, melt and pour in to the vessel which contains *go-dugdha* or *bhṛṅgarāja svarasa*. Collect on cooling to room temperature, wash with plenty of luke warm water, dry, prepare the fine powder and preserve for further purpose.

8. *Gandhaka* has the following attributes:

8.1 Properties and Actions:

Rasa	-	Madhura, Kaṭu, Tikta, Kaṣāya
Guṇa	-	Uṣṇa, Sara, Snigdha
Vīrya	-	Uṣṇa
Vipāka	-	Kaṭu

Karma - Rasāyana, Dīpana, Pācana, Viśahara, Kaphahara, Balya, Medhya, Pittala, Cakṣuṣya, Kṛmihara, Sūtajit, Kuṣṭhahara, Āmaśoṣahara, Sūtendravīryapada, Vātahara,

8.2. Therapeutic Uses of śuddha Gandhaka: Kaṇḍū (itching); Kuṣṭha (diseases of the skin); Visarpa (erysepales); Dadru (taeniasis); Āmavāta (rheumatism); Kapha roga (disease due to kapha doṣa); Garaviṣa (slow/accumulated poison); Plīhā roga (splenic disease); Kṣaya (pthisis); Kāsa (cough); Śvāsa (Asthma); Netra roga (diseases of eyes); Vāta roga (diseases due to Vāta doṣa)

9. **Dose:** 125 mg - 1 g of śuddha *Gandhaka*.

10. **Important Formulations:** - Mahāgandhaka vaṭī, Pañcāmṛta parpaṭī, Candrakalā rasa, Taruṇārka rasa, Rasa parpaṭī, Gandhaka rasāyana.

GODANTĪ

(Selenite)

1. **Definition:** *Godantī* is Selenite ($\text{CaSO}_4, 2\text{H}_2\text{O}$) mineral.

2. **Synonyms:**

2.1 **Sanskṛta** : *Godanta*

2.2 **Names in other Languages:**

English	-	Selenite, Gypsum
Gujarati	-	Godantī, Ghāpaṇa, Chirodī
Hindi	-	Godanti
Marathi	-	Godantī, Śiragola
Tamil	-	Karpura Chilajattu (S.F.I.)
Telugu	-	Hara sothamu
Urdu	-	Godanti (N.F.U.M.)

3. **Broad Classification:** Hydrous calcium sulphate

4. **Origin and occurrence:** *Godantī* occurs as evaporates; extensive sedimentary deposits interbedded with limestone, red shales and clay stones etc. It occurs generally in pure mineral form.

In India, significant occurrences of *Godantī* are at Nellore, Prakasam and Guntur in Andhra Pradesh and Bikaner, Barmer, Jaisalmer, Nagaur, Ganganagar and Pali in Rajasthan. Major production of *Godantī* comes from these two states only. There are some other occurrences also reported in the states of Gujarat, Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh and Tamil Nadu.

5. **Physical properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix –1).

Nature	:	Crystalline showing elongated tabular crystals
Colour	:	Greyish white
Streak	:	White
Cleavage	:	Perfect
Fracture	:	Even
Lustre	:	Silky
Tenacity	:	Sectile
Transparency	:	Translucent
Hardness	:	2
Sp. Gr.	:	2 to 2.5

6. **Optical properties:** Anisotropic, biaxial positive, large $2V$, weak birefringence.
Refractive index : $\eta_\alpha, 1.520$; $\eta_\beta, 1.524$; $\eta_\gamma, 1.530$ (Appendix–2).

7. Chemical Properties:

- 7.1 Test for sulphate radical:** Take about 0.5 g powdered sample in a test tube. Add 10-15 ml dilute *hydrochloric acid* and boil. Add 10 % *barium chloride solution* drop wise. The resulting solution gives white precipitate of barium sulphate.
- 7.2 Assay:** Should contain not less than 20% Calcium (Ca) or 30% calcium oxide (CaO) when analysed by gravimetric method (Appendix-3.1.5).
- 7.3 Heavy metals and Arsenic:** Should not contain more than the stated limits for the following: Lead = 6 ppm, Arsenic = 1 ppm and Cadmium = 4 ppm (Appendix-3.2).

8. Śodhana: Shall not be used in formulations without subjecting it to śodhana.

9. *Godantī* is used in the form of *bhasma*, the details of which are given in the monograph of *bhasma*.

GOMEDA (Garnet)

1. **Definition:** *Gomeda* is Almandite $\{Fe_3Al_2(SiO_4)_3\}$, one of the garnet group of minerals.

2. **Synonyms:**

2.1 **Names in other Languages:**

Bangali	-	Gomeda
English	-	Garnet
Gujarati	-	Gomeda
Hindi	-	Gomeda
Marathi	-	Gomeda
Telugu	-	Gomedikamu

3. **Broad Classification:** Silicate of iron and aluminium

4. **Origin and occurrence:** *Gomeda* occurs in two forms; in-situ deposits and placers. It occurs as in-situ deposits in metamorphic rocks, mostly in schists and gneisses, of argillaceous parentage, crystalline limestone and metamorphosed basic and other igneous rocks. In placer form, it is found as heavy detrital residue in sediments.

In India, in-situ occurrences of *Gomeda* exist in many parts of the country e.g. Khammam in Andhra Pradesh, Singbhum in Jharkhand, Hassan, Bangalore and Mysore in Karnataka and Ajmer, Bhilwara, Jhujhunu, Sikar, Sirohi and Tonk in Rajasthan. It occurs as primary mineral also in igneous rocks such as mica-pegmatites of Bihar, Andhra Pradesh and Rajasthan. The placer deposits, whereas, occur in beach sands of Kerala, Tamil Nadu and Orissa.

Varieties of *Gomeda* are valued as semi-precious stones.

5. **Physical properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix -1).

Nature	:	Crystal
Colour	:	Reddish brown
Streak	:	White
Cleavage	:	Not present
Fracture	:	Sub-conchoidal
Lustre	:	Vitreous to resinous
Tenacity	:	Brittle
Transparency	:	Translucent
Hardness	:	7.0 to 7.5
Sp. Gr.	:	3.5 to 4.0
Fluorescence	:	No fluorescence when observed after irradiation with UV rays of 365 to 400 nm

6. **Optical properties:** Isotropic
Refractive Index: $n = 1.83$ (range 1.75 to 1.90) (Appendix-2.4).
7. **Chemical Properties:**
- 7.1 **Assay:** Should contain not less than 35% SiO_2 , 10% Alumina (Al_2O_3) and 5% Iron (Fe) when analysed by gravimetric method (Appendix-3.1).
- 7.2 **Heavy metals and Arsenic:** Should not contain more than the stated limits for the following: - Mercury = 7 ng/g, Arsenic = 2 ppm and Cadmium = traces (Appendix-3.2).
- 7.3 **Other Elements:** May contain the following within $\pm 20\%$ of the stated limits:- Calcium = 0.10 %, Magnesium = 0.10 % and Manganese = 11% (Appendix-3.1 & 3.2).
8. **Distinction from Manikyam:**
Māṇikyā gives a fiery red fluorescence in near UV rays of 365 to 400nm, whereas *Gomeda* does not fluoresce under the same condition. *Māṇikyā* is anisotropic, uniaxial and negative.
9. **Śodhana:** Shall not be used in formulations without subjecting it to śodhana.
- 9.1 **Śodhana:** [Ref: Rasa Taraṅgiṇī-23/123]
- | | | |
|--------------------------|---------|-----------------|
| i) <i>Gomeda</i> | : | 1 Part |
| ii) <i>Nimbū svarasa</i> | [Fr.] : | Q.S for Svedana |
- Method:**
Prepare small pieces of *Gomeda*, boil in *Nimbū svarasa* for 3 hours. On cooling to room temperature, collect *Gomeda*, dry and use for therapeutic purposes.
10. *Gomeda* is used in the form of *piṣṭī* or *bhasma*, the details of which are given in the monograph of *piṣṭī* or *bhasma*.

JAHARAMOHARĀ

(Serpentine)

1. **Definition:** *Jaharamoharā* is Serpentine, a hydrous silicate of Magnesium [$\text{Mg}_6(\text{Si}_4\text{O}_{10})\text{X}(\text{OH})_8$]. This is also known as Green Marble in trade.

2. **Synonyms:**

2.1 **Saṁskṛta** : *Jaharamoharā*

2.2 **Names in other Languages:**

English - Serpentine, Green Marble

Hindi - Jaharamoharā

Telugu - Śālagrāma śilā

Urdu - Zahar Mohra, Hajr-us-sum, Fad Zahr Madani, Hajr-ul-behr (N.F.U.M.)

3. **Broad Classification:** Hydrous magnesium silicate

4. **Origin and occurrence:** *Jaharamoharā* results from the alteration, either during metamorphism or by late-stage hydrothermal action at temperatures below 400° , of rocks rich in magnesium, containing olivine, pyroxene or amphibole. Magnetite usually accompanies this alteration. Some serpentine occurs as large rock masses generally referred to as serpentinites. Nickel in minor amount is generally present in *Jaharamoharā*. A little amount of Calcium, Iron and Aluminium may also be present.

In India, *Jaharamoharā* occurs mostly in metamorphic terrains of Rajasthan, Karnataka, Jharkhand, Madhya Pradesh and Andhra Pradesh. In Rajasthan, it occurs abundantly in Udaipur and Dungurpur districts.

5. **Physical properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix -1).

Nature	:	Crystalline, coarse grained, soapy feel
Colour	:	Blackish green
Streak	:	Colourless
Cleavage	:	Perfect
Fracture	:	Conchoidal
Lustre	:	Greasy
Tenacity	:	Tough
Transparency	:	Translucent
Hardness	:	3.5 to 5
Sp. Gr.	:	2.5 to 2.7

6. **Optical properties :** Bi-axial, negative, weakly birefringent with R.I. 1.546 to 1.554 (Appendix- 2).

7. Chemical Properties:

7.1 Effect of Heat: Take about 1 g powdered sample of *Jaharamoharā* in open test tube. Heat the test tube at around 500°. The sample gets decomposed and gives off a little water.

7.2 Assay:

7.2.1 Should contain not less than 30% magnesium oxide when analysed by gravimetric method (Appendix-3.1.6).

7.2.2 Should contain not less than 30 % Silica (SiO₂), not less than 5% Ferric oxide (Fe₂O₃) and not less than 5% calcium oxide (CaO) when analysed by gravimetric method (Appendix -3.1).

7.2.3 Heavy metals and Arsenic: *Jaharamoharā* should not contain more than the stated limits for the following: - Arsenic = 2 ppm and Cadmium = 3 ppm (Appendix-3.2).

7.2.4 Other elements: May contain the following within ± 20% of the stated limits:- 0.15 % Nickel when analysed by Atomic Absorption Spectrophotometer (Appendix-3.2.2).

8. Śodhana: Shall not be used in formulations without subjecting it to śodhana.

8.1 Śodhana: [Ref. Rasatantrasāra Siddha Prayoga Saṅgraha, Part-1, Page 73]

- | | | | |
|-----|---------------------|---|--------|
| i) | <i>Jaharamoharā</i> | : | 1 part |
| ii) | Go-dugdha | : | Q.S |
| | or | | |
| | Āmalakī rasa | | |

Method:

Heat *Jaharamoharā* till it becomes red hot and dip in *Go-dugdha* or *Āmalakī rasa* for 21 times.

9. *Jaharamoharā* is used in the form of piṣṭī, the details of which are given in the monograph of piṣṭī.

KĀNTA LAUHA (Iron Ore)

1. **Definition:** *Kānta Lauha* is an Iron ore containing magnetite, a ferric oxide (Fe_3O_4) mineral.

2. **Synonyms:**

2.1 **Saṁskṛta** : *Kānta, Kāntaka, Kāntāyasa*

2.2 **Names in other Languages:**

English	-	Magnetite
Gujarati	-	Nātisa
Hindi	-	Cumbaka, Cumbaka patthar
Tamil	-	Kantham (S.F.I.)
Telugu	-	Sudantu rāyi, Ayaskāntamu
Urdu	-	Faulad, Aahan (N.F.U.M.)

3. **Broad Classification:** Oxide

4. **Origin and occurrence:** *Kānta Lauha* occurs in igneous as well as metamorphic rocks as accessory mineral. It is a wide-spread oxide mineral found in earth's crust in ore form. *Kānta Lauha* is commonly associated with hematite (Fe_2O_3).

In India, *Kānta Lauha* occurs mainly at Guntur in Andhra Pradesh, Salem and Tirucirappalli in Tamil Nadu, Shimoga and Kudramukh in Karnataka, Mandi in Himachal Pradesh, Mayurbhanj in Orissa and Noamundi, Notoburu, Gore Pahar and Biwabathan in Jharkhand. Other known deposits with hematite as predominant mineral occur in the states of Bihar, Goa, Madhya Pradesh and Rajasthan.

5. **Physical Properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix –1).

Nature	:	Lump
Colour	:	Greyish black
Streak	:	Reddish black
Cleavage	:	None
Fracture	:	Uneven
Lustre	:	Metallic
Tenacity	:	Brittle
Transparency	:	Opaque
Magnetism	:	Magnetic in nature
Hardness	:	5.5 to 6
Sp.Gr	:	5 to 6

6. Chemical Properties:

6.1 Assay:

Kānta Lauha in ore form should contain not less than 60% Iron (Fe) when analysed by gravimetric method (Appendix-3.1.4).

6.2 Heavy metals and Arsenic: *Kānta Lauha* in ore form should not contain more than the stated limits for the following: - Arsenic = 2 ppm and Cadmium = 7 ppm (Appendix-3.2).

6.3 Other Elements: *Kānta Lauha* in ore form may contain the following within $\pm 20\%$ of the stated limits:- Zinc = 95 ppm, Manganese = 500 ppm and Silver = 5 ppm (Appendix-3.1 & 3.2).

6.4 Acid Insoluble: Take about 1 g of pre-dried finely powdered (150 mesh) sample of *Kānta Lauha* in 250 ml beaker. Add 50 ml dilute *hydrochloric acid*. Stir the solution and cover the beaker with a watch glass. Heat on the hot plate at 150° and digest for two hours. Cool, filter in buchner funnel, wash with water and ignite at 900° . Weigh the residue. It should not be more than 13 % of the initial weight of the sample.

7. Śodhana: Shall not be used in formulations without subjecting it to śodhana.

8. *Kānta Lauha* is used in the form of *bhasma*, the details of which are given in the monograph of *bhasma*.

KĀŚĪŚĀ (Ferrous Sulphate)

1. **Definition:** *Kāśīśa* is Ferrous Sulphate ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) also known as Green vitriol, Copper as or melanterite mineral.
2. **Synonyms:**
 - 2.1 **Saṃskṛta** : *Kāśīśaka, Puṣpakāśīśa*
 - 2.2 **Names in other Languages:**

Bangali	-	Hirākas
English	-	Ferrous Sulphate, Green vitriol
Gujarati	-	Hirākasī
Hindi	-	Kasīs, HīraKasīs
Kannada	-	Kaasisa, Annabedi
Malayalam	-	Turusi, Turus
Marathi	-	Hirākas
Tamil	-	Annabedhi, Annapeti (S.F.I.)
Telugu	-	Annabhedi
Urdu	-	Hira Kasees, Zaj-e-Asfar, Tutia-e-Sabz (N.F.U.M.)
3. **Broad Classification:** Hydrous ferrous sulphate
4. **Origin and occurrence:** *Kāśīśa*, a secondary mineral, results from the decomposition of pyrites in the zone of oxidation and is found in small quantities wherever pyrite occurs. It occurs widely as efflorescence on the walls and timbers of mine workings. *Kāśīśa* is commonly associated with chalcantite, gypsum and other hydrous basic sulphates. Mostly, commercially manufactured *Kāśīśa* as a chemical is used for Ayurvedic formulations in the country.
5. **Physical properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix –1).

Nature	:	Massive lumps
Colour	:	Greenish white
Streak	:	White
Cleavage	:	None
Fracture	:	Uneven
Lustre	:	Earthy
Tenacity	:	Brittle
Transparency	:	Translucent
Hardness	:	1.95 to 2
Sp. Gr.	:	1.90 to 1.97
Taste	:	Sweetish, astringent taste

6. Chemical Properties:

6.1 Effect of Heat:

6.1.1 Heated before blowpipe, *Kāśīśa* becomes magnetic as felt by a horse-shoe magnet.

6.1.2 On strong heating in a crucible, *Kāśīśa* loses water with evolution of SO₂ gas giving pungent smell of burning sulphur.

6.1.3 Take about 5 g fine powder each of *Kāśīśa* and borax. Heat the mixture in a crucible. A brown glassy fused mass results.

6.1.4 Efflorescence: *Kāśīśa* is efflorescent in dry air. On exposure to moist air, the *Kāśīśa* crystals rapidly oxidize and become coated with brownish yellow mass.

6.2 **Reaction with barium chloride solution:** White precipitate of barium sulphate appears on addition of *barium chloride solution* in *Kāśīśa* solution, dissolved in *purified water*.

6.3 **Solubility in water:** Take about 10 g accurately weighed fine (150 mesh) powder of *Kāśīśa* in 250 ml beaker. Add 50 ml *purified water* to it. Stir the solution till *Kāśīśa* powder stops dissolving. Put the beaker in the sun light till the solution gets completely dried up. Weigh the residue, if any. It should not be more than 5% of the initial weight of the sample. That is, solubility of *Kāśīśa* in *purified water* should not be less than 95%.

6.4 **Assay:** *Kāśīśa* should contain not less than 25% Iron, not less than 15% Sulphur and not less than 45% SO₄ (Appendix-3.1 & 3.3).

6.5 **Heavy metals and Arsenic:** *Kāśīśa* should not contain more than the stated limits for the following: - Arsenic = 2 ppm and Cadmium = 2 ppm (Appendix-3.2).

6.6 **Other elements:** May contain the following within $\pm 20\%$ of the stated limits:- Copper (Cu) 188 ppm when analysed by Atomic Absorption Spectrophotometer method (Appendix-3.1.9 & 3.2.2).

7. **Śodhana :** - Shall not be used in formulations without subjecting it to śodhana.

7.1 **Śodhana:** [Ref: AFI-Part-I; Appendix-II, Śodhana-6]

- | | | |
|-----------------------------------|---|------------------|
| i) <i>Kāśīśa</i> | : | 1 Part |
| ii) Bhṛṅganīra (Bhṛṅgarāja) [Pl.] | : | Q.S. for Bhāvanā |

Method:

Powder *kāsīsa*, add quantity sufficient *bhṛṅgarāja svarasa* and grind till complete moisture gets evaporated. Repeat the process for three times.

8. *Kāsīsa* has the following attributes:

8.1 Properties and Actions:

Rasa	-	Amla, Tikta, Kaṣāya.
Guṇa	-	Uṣṇa
Vīrya	-	Uṣṇa
Vipāka	-	Kaṭu
Karma	-	Vāta-Kaphahara, Keśya, Netrya, Rajaḥ pravartaka, Kṛṣṇīkaraṇa, Saṅkocaka (Astringent), Balya, Keśya Rañjana, Rakta vardhaka

8.2. **Therapeutic Uses:** kaṇḍū (itching); viṣa roga (disease due to poison); Mūtrakṛcchra (dysuria); Aśmarī (calculus); Śvitra (Leucoderma / Vitiligo); Pitta Apasmāra (Epilepsy due to Pitta doṣa); Pāṇḍu (anaemia); Plīhāvṛddhi (splenomegaly); Kṛmi (Helminthiasis/ worm infestation); Gudabhraṁśa (prolapse of rectum); Visarapa (Erysepales); Netra roga (disease of eyes); Śleṣma roga (disease due to kapha doṣa)

9. **Dose:** 60 – 250 mg

10. **Important Formulations:** Rajaḥpravartinī vaṭī, Kāsīsādi taila, Kāsīsādi ghṛta, Śaṅkha drāvaka, Plīhāri vaṭikā

KHAṬIKĀ (Kaolinite)

1. **Definition:** *Khaṭikā* is Kaolinite ($\text{Al}_2(\text{Si}_2\text{O}_5)(\text{OH})_4$), an aggregate of minerals and colloidal substances commonly known as Clay.

2. **Synonyms:**

2.1 **Names in other Languages:**

Bangali	-	Khaḍi, Phula Khaḍi
English	-	Clay
Gujarati	-	Khaḍi, Khaḍimāṭī
Hindi	-	Khaḍiya, Khariya, Khaḍi
Marathi	-	Khaḍu
Telugu	-	Sima sunnamu, Sudhā

3. **Broad Classification:** A phyllo-silicate of aluminium

4. **Origin and occurrence:** *Khaṭikā* occurs associated with pre-cambrian granites, gneisses, pegmatites, phyllites and schists; gondwana shales and sand stones as bedded deposits. *Khaṭikā* is formed by the decomposition of other aluminosilicates (feldspars) either by weathering or by hydrothermal activity. It occurs in pure mineral form as lumps consisting of very small particles.

In India, *Khaṭikā* occurs at several places in different states. Most significant occurrences are Ajmer, Udaipur, Chittorgarh, Bikaner, Barmer and Sawai Madhopur in Rajasthan, Bankura, Birbhum, Purulia and Darjeeling in West Bengal, Chinglaput, Ramanathapuram and South Arcot in Tamil Nadu, Koraput, Cuttak, Keonjhar and Mayurbhanj in Orissa, Cuddapah, Godavari area, Vishakhapatnam and Nellore in Andhra Pradesh, Trivendrum, Ernakulam, Palakkad and Kannur in Kerala and Singhbhum, Bhagalpur, Santhal, Ranchi and Gaya in Jharkhand.

5. **Physical properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix -1).

Nature	:	Lumps (whitish to occasionally coloured layers) with greasy feel and earthy odour
Colour	:	Whitish, occasionally tinted
Streak	:	White
Cleavage	:	Not observable
Fracture	:	None
Lustre	:	Vitreous
Tenacity	:	Brittle
Transparency	:	Translucent
Hardness	:	2 to 3
Sp.Gr	:	2 to 3

6. Chemical Properties:

- 6.1 Assay:** *Khaṭikā* should contain not more than 50% Silica (SiO_2) and not less than 30% Alumina (Al_2O_3) when analysed by gravimetric method (Appendix-3.1).
- 6.2 Heavy metals and Arsenic:** *Khaṭikā* should not contain more than the stated limits for the following: - Lead = 15 ppm, Arsenic = 2 ppm and Cadmium = 7 ppm (Appendix-3.2).
- 6.3 Other Elements:** May contain the following within $\pm 20\%$ of the stated limits:- Calcium = 0.32%, Magnesium = 0.78% with negligible amount of Manganese (20 ppm) and Chromium (250 ppm) (Appendix-3.1 & 3.2).
- 6.4 Distinctive Properties:**
- 6.4.1** Take a small quantity of *Khaṭikā* powder on a micro slide. Mix with one or two drops of *alcoholic methylene blue solution* (1% w/v in 95% alcohol). Drop a cover slip and examine under medium or low power. Most particles are stained a deep blue (distinction from talc, which is not stained blue).
- 6.4.2** Take a small quantity of *Khaṭikā* powder on a micro slide. Mix with *safranin solution* (1% w/v in 70% alcohol). Drop a cover slip and examine under medium or low power. None or occasionally very few particles are coloured red (distinction from bentonite, where all particles are stained deep red).
- 6.4.3** Place a small quantity of *Khaṭikā* powder in a watch glass and add a few drops of dilute *hydrochloric acid*. No gas or bubbles evolved (distinction from chalk).
- 6.4.4** Place a small quantity of *Khaṭikā* powder (150 mesh) on a micro slide and put a cover slip on to make a dry mount. Now add a drop or two of *purified water* to the edge of the cover slip and allow the water to flow under the cover slip. The water should spread through the powder, which gets easily dispersed without forming a gel (distinction from bentonite and other clays that would swell and form a gel around the edge).

7. Śodhana: Shall not be used in formulations without subjecting it to śodhana.

- 7.1 Śodhana:** [Rasa Tarāṅgī. 21/210]

Method:

Wash in sufficient quantity of *purified water*, filter through a clean cloth and use for therapeutic purposes.

8. ***Khaṭikā*** has the following attributes:-

8.1. **Properties and actions:**

Rasa	-	Tikta, Madhura
Guṇa	-	Śīta
Vīrya	-	Śīta
Vipāka	-	Madhura
Karma	-	Pitta śāmaka, Vraṇa ropāṇa, Kapha-dāha-rakta-doṣaghnī, Svedādisrāvahara

8.2 **Therapeutic Uses of Śuddha *Khaṭikā*:** Śoṭha (inflammation); Netra roga (diseases of eyes); Atīsāra (diarrhoea)

8.3 **External use:** Tvak roga (skin disease); Mukh-danta roga (disease of mouth and tooth) and Dāha (burning sensation)

9. **Dose:** ½ - 1 g of śuddha *Khaṭikā* for both internal & external use

9.1. **Anupāna:** To be taken along with cold water.

10. **Important Formulations:** Daśana saṁskāra cūrṇa (for external)

MAṆḌŪRA (Iron Slag)

1. **Definition** : *Maṇḍūra* is a metallic oxide-cum-silicate of iron, generally having the composition Fe_2SiO_4 and commonly called Slag.

2. **Synonyms:**

2.1 **Saṁskṛta** : *Kiṭṭa, Lohamala, Loha Kiṭṭa*

2.2 **Names in other Languages:**

English	-	Slag
Gujarati	-	Maṇḍūra
Hindi	-	Maṇḍūra, Loha kīṭa, Siṅghaṇaka
Kannada	-	Loha kitta
Malayalam	-	Ierumbin Kittam
Marathi	-	Maṇḍūra
Tamil	-	Manturam, Irumbukittam (S.F.I.)
Telugu	-	Loha kittam
Urdu	-	Khabus-ul-Hadeed, Zang-e-Aahan (N.F.U.M.)

3. **Broad Classification:** Metallic oxide-cum-silicate

4. **Origin and occurrence:** *Maṇḍūra* is the by-product of the metallurgical process during extraction of Iron (Fe) and Copper (Cu) from their respective ores. It occurs as lumps, boulders or aggregates at the areas where smelting activity is carried out for the extraction of copper and iron. Iron is the main constituent of *Maṇḍūra* followed by Silica with minor amounts of Cu, S, Pb, Zn, Ag, Cd and Au.

Maṇḍūra is known since ancient times in India and occurs in over 500 years old slag dumps near village Singhana (Khetri), distt. Jhunjhunu (Rajasthan). *Maṇḍūra* of similar quality may occur at other places also in the country where smelting of copper ore was carried out in the past.

5. **Physical Properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix –1).

Nature	:	Rough lumpy masses, exhibiting voids
Colour	:	Black
Streak	:	Black
Cleavage	:	None
Fracture	:	Conchoidal
Lustre	:	Dull
Tenacity	:	Brittle but hard
Transparency	:	Opaque
Magnetism	:	Non-magnetic
Hardness	:	6 to 6.5
Sp. Gr.	:	3 to 3.8

6. Chemical properties:

6.1 Assay:

6.1.1 *Mañḍūra* should contain not less than 30% Iron (Fe) when analysed by gravimetric method (Appendix-3.1.4).

6.2.1 *Mañḍūra* should contain not less than 30% Silica when analysed by gravimetric method (Appendix-3.1.3).

6.1.3 *Mañḍūra* should show not less than 80% fayalite (Fe_2SiO_4) when studied through XRD method (Appendix- 1.13).

6.2 Heavy metals and Arsenic: *Mañḍūra* should not contain more than the stated limits for the following: - Arsenic = 6 ppm and Cadmium = 8 ppm (Appendix-3.2).

6.3 Other Elements: May contain the following within $\pm 20\%$ of the stated limits:- Copper = 0.45%, Zinc = 50 ppm and Silver = 7 ppm (Appendix-3.2).

7. Śodhana : *Mañḍūra* shall not be used in formulations without subjecting it to śodhana.

8. *Mañḍūra* is used in the form of *bhasma*, the details of which are given in the monograph of *bhasma*.

RAJATA

(Silver metal)

1. **Definition:** *Rajata* (Ag) is a silver- white metal available in the form of ingots.
2. **Synonyms:**
 - 2.1 **Saṁskṛta** : *Candra, Raupya, Tāra, Rūpyaka, Rūpya, Rūpyamala*
 - 2.2 **Names in other Languages:**

Bangali	-	Rūpā
English	-	Silver
Gujarati	-	Rūpum, Cāndī
Hindi	-	Cāndī, Rūpā
Latin	-	Argentum
Marathi	-	Cāndī, Rupe
Telugu	-	Vendi
3. **Broad Classification:** Metal
4. **Origin and occurrence:** *Rajata* occurs in nature in the free state, occasionally 99% pure, but generally containing copper, gold and other metals. Native *Rajata* occurs in the earth's crust in two principal ways:
 - (i) as small amounts in the oxidised zone of ore deposits and
 - (ii) as deposits from hydrothermal solutions. It occurs with sulphides, zeolites, calcite, barite, fluorite and quartz. Native *Rajata* is much rare in occurrence than native *Svarṇa* but is widely distributed in small amounts. In recent years, much of the total *Rajata* production has been obtained as by-product of gold refining. It is obtained from its ores mainly by amalgamation with mercury or by cyanidation if present in a finely divided state. If not finely divided, the ores are concentrated and smelted. But largely *Rajata* is derived from smelting of Lead, Zinc and Copper ores which are argentiferous. Pure *Rajata* may contain *Svarṇa* (Au) up to 10% with trace amounts of Cu and sometimes Pt, Sb, Bi, As and Hg.

In India, there are no *Rajata* deposits as such. It is found associated mainly with lead and zinc and to some extent with copper and gold. All galena (lead ore) deposits of Zawar, Rajpura-Dariba, Deri-Basantgarh and Rampura-Aghucha in Rajasthan, Sargipalli in Orissa, Zangamarajupal, Bandalamotu and Nallakonda in Andhra Pradesh, Hesatu-Belhathan in Bihar and Pauri-Garhwal in Uttaranchal invariably contain *Rajata*. It is available in market in the form of ingots.

5. **Physical properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix –1).

Nature	:	Granular, nuggets and feather like dendrites
Colour	:	Silver white, turning greyish black due to tarnishing
Streak	:	White
Cleavage	:	None
Fracture	:	Hackly
Lustre	:	Metallic
Tenacity	:	Sectile, ductile and malleable
Transparency	:	Opaque
Hardness	:	2.5 to 3.0
Sp.Gr	:	10.1 to 11.1

6. **Chemical Properties:**

6.1 **Reaction with Acids:** Prepare solution of *Rajata* in *nitric acid* and add *hydrochloric acid* to it. A dense white curdy precipitate of silver chloride is produced. This precipitate is soluble in *ammonia*.

6.2 **Solubility:** Soluble in *nitric acid*.

6.3 **Assay:** *Rajata* should contain not less than 98.5% Silver (Ag) when analysed by A. A. S. (Appendix-3.2.1).

6.4 **Heavy metals and Arsenic:** In *Rajata* Mercury, Lead, Arsenic and Cadmium should be absent.

6.5 **Other Elements:** May contain the following within $\pm 20\%$ of the stated limits:- Copper = 1.40 %, Sulphur = traces and Gold = 0.001% (Appendix-3.1 & 3.2).

7. **Śodhana:** Shall not be used in formulations without subjecting it to śodhana.

8. *Rajata* is used in the form of *bhasma*, the details of which are given in the monograph of *bhasma*.

SĀMUDRA LAVAṆA

(Sea Salt)

1. **Definition:** *Sāmudra Lavaṇa* is a halite mineral, described as Sea salt (NaCl).

2. **Synonyms:**

2.1 **Saṁskṛta :** *Sāmudra, Sāmudraka*

2.2 **Names in other Languages:**

Bangali	-	Karakaca
English	-	Sea salt
Gujarati	-	Mīṭhu
Hindi	-	Pāṅgā, Pāṅgānona, Samudri Namak
Kannada	-	Hojatha
Marathi	-	Mīṭha
Tamil	-	Soruppu, Uppu (S.F.I.)
Telugu	-	Samudrapu Uppu

3. **Broad Classification:** Halite

4. **Origin and occurrence:** *Sāmudra Lavaṇa* is formed as extensive irregular beds due to evaporation of seawater in saltpans along seashores in India. *Sāmudra Lavaṇa* occurs in association with gypsum, poly halite, anhydrite, clay, sand stone and calcite etc. in these pans. Some commercial saltpans, known as source of *Sāmudra Lavaṇa* in India, are Thuthukkudi (Tuticorin) in Tamilnadu, Cambay in Gujarat and Sambar Lake in Rajasthan.

5. **Physical properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix –1).

Nature	:	Crystalline coarse grained aggregates
Colour	:	White / off white
Streak	:	None
Cleavage	:	Perfect cubic
Fracture	:	Conchoidal
Lustre	:	Vitreous
Tenacity	:	Brittle
Transparency	:	Transparent
Hardness	:	2.5
Sp. Gr.	:	1.98 to 2.2
Taste	:	Salty

6. **Optical properties:**

Isotropic with R.I. 1.540 to 1.544 (Appendix-2)

7. Chemical Properties:

7.1 Effect of Heat:

7.1.1 Take a crystal of *Sāmudra Lavaṇa* on a porcelain plate. Blow a burner flame through blowpipe over the *Lavaṇa*. The colour of the flame becomes deep yellow indicating the presence of sodium.

7.1.2 When heated through blowpipe, *Sāmudra Lavaṇa* crackles and decrepitates and on addition of copper oxide to it, gives the usual blue chlorine flame (Appendix-3.4.3).

7.2 **Reaction with silver nitrate:** Take 5 g *Sāmudra Lavaṇa* and dissolve it in *purified water*. Add a freshly prepared 5% w/v solution of *silver nitrate* (AgNO_3) in *purified water*, drop by drop, to this *Lavaṇa* solution. A white precipitate of *silver chloride* (AgCl) forms.

7.3 Assay:

7.3.1 *Sāmudra Lavaṇa* should contain not less than 35% Sodium (Na) when analysed by flame photometry (Appendix-3.2.13).

7.3.2 *Sāmudra Lavaṇa* should contain not less than 58% Chlorine (Cl) (Appendix-3.1.10).

7.4 **Heavy metals and Arsenic:** *Sāmudra Lavaṇa* should not contain more than the stated limits for the following: - Lead = 12 ppm, Arsenic = 4 ppm and Cadmium = 4 ppm (Appendix-3.2).

8. *Sāmudra Lavaṇa* has the following attributes:

8.1 Properties and Actions:

Rasa	-	Lavaṇa
Guṇa	-	Snigdha, Laghu, Uṣṇa
Vīrya	-	Nāti Uṣṇa / Nāti Śīṭala
Vipāka	-	Madhura
Karma	-	Vāta-hara, Hṛdya, Bhedī, Rucikara, Dīpana, Kaphahara, Śūlaghna, Avidāhī, Īṣat Pittala, Snehana, Pācana, Kledana, Balya

8.2 **Therapeutic Uses:** Ajīrṇa (dyspepsia), Śoṣa (cachexia), Jīrṇa carma roga (chronic skin diseases), Galagaṇḍa (goiter), Pāṇḍu (anaemia), Pratiśyāya (coryza)

9. Dose - According to formulation

10. Important Formulations: Lavaṇa Bhāskara cūrṇa, Sāmudrādyā cūrṇa, Nārāyaṇa cūrṇa, Mahāśaṅkha vaṭī, Kalyāṇaka guḍa

SAUVĪRĀÑJANA

(Lead Ore)

1. **Definition:** *Sauvīrāñjana* is a lead ore containing galena (PbS) mineral.

2. **Synonyms:**

2.1 **Saṁskṛta** : *Nīlāñjana, Kṛṣṇāñjana*

2.2 **Names in other Languages:**

Bangali	-	Suramā
English	-	Galena, Lead ore
Gujarati	-	Suramo
Hindi	-	Suramā, Kālā Suramā
Marathi	-	Suramā
Tamil	-	Vangam (S.F.I.)
Telugu	-	Sauvirāñjanamu, Surmā rayi
Urdu	-	Surmah Siyah, Kohal Isphahani, Sang-e-surma (N.F.U.M.)

3. **Broad Classification:** Sulphide

4. **Origin and occurrence:** *Sauvīrāñjana* occurs in metamorphic as well as sedimentary rocks in the form of disseminations, veins or lodes. It occurs mostly in pure cubic crystal form and also in ore form associated with rock mass. *Sauvīrāñjana* invariably occurs in association with sphalerite (ZnS), their host rock generally being limestone, dolomite and other calc-magnesium rich rocks. Chalcopyrite and pyrite may co-occur in small amount. Silver in minor quantity is always associated. Trace amount of Arsenic, Iron, Cadmium, Gold, Bismuth and Antimony is also reported in *Sauvīrāñjana*.

In India, *Sauvīrāñjana* occurs mostly at Zawar, Aghucha, Rajpura-Dariba, Deri - Basanthgarh and Gugra in Rajasthan, Bandalamottu and Zangamarajupal in Andhra Pradesh, Ambaji in Gujarat, Sargipalli in Orissa and Gorubathan in West Bengal. Mining of *Sauvīrāñjana* from most of these areas is carried out by Hindustan Zinc Limited (A unit of *Vedanta*), producing more than 90% lead ore in the country.

5. **Physical Properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix –1).

Nature	:	Usually lumps and heavy cubic crystals
Colour	:	Grey
Streak	:	Grey
Cleavage	:	Cubic
Fracture	:	Even
Lustre	:	Metallic
Tenacity	:	Brittle
Transparency	:	Opaque

Hardness	:	2 to 3
Sp. Gr.	:	7 to 8

6. Chemical properties:

6.1 Charcoal Test: When heated on charcoal through blow pipe, *Sauvīrāñjana* fuses easily, emits sulphurous fumes and on continued heating yields a globule of metallic lead (Appendix-3.4.4).

6.2 Effect of Acids:

6.2.1 Take about 5 g of finely powdered (150 mesh) *Sauvīrāñjana* in a test tube. Add 10 ml dilute *nitric acid* and heat. It evolves brownish fumes.

6.2.2 Take about 5 g finely powdered (150 mesh) *Sauvīrāñjana* in a test tube. Add 10 ml dilute *hydrochloric acid* and heat. It evolves *hydrogen sulphide* (H_2S) gas, as detected by its odour of rotten eggs.

6.3 Assay:

6.3.1 *Sauvīrāñjana* in ore form should contain not less than 50% Lead (Pb) when analysed by A. A. S. (Appendix-3.2.2).

6.3.2 *Sauvīrāñjana* in ore form should contain not less than 10% Sulphur when analysed by gravimetric method (Appendix-3.1.8).

6.3.3 *Sauvīrāñjana* in ore form should contain not less than 500 ppm Silver (Ag) when analysed by A. A. S. (Appendix-3.2.1).

6.4 Heavy metals and Arsenic: *Sauvīrāñjana* in ore form should not contain more than the stated limits for the following: - Arsenic = 2 ppm and Cadmium = 22 ppm (Appendix-3.2).

6.5 Other Elements: *Sauvīrāñjana* in ore form may contain the following within $\pm 20\%$ of the stated limits:- Copper = 70 ppm, Gold = 0.10 ppm and Zinc = 20 ppm (Appendix-3.1 & 3.2).

7. Distinction from Śrotonjana: Cubic cleavage, greater Sp.Gravity and darker colour of *Sauvīrāñjana* distinguish it from *Śrotonjana* (Sb_2S_3).

8. Śodhana: Shall not be used in formulations without subjecting it to *śodhana*.

8.1 Śodhana: [Ref: AFI-Part-1; Appendix-II, Śodhana-3]

- | | | |
|-----------------------------------|---|------------------|
| i) <i>Añjana</i> | : | 1 part |
| ii) <i>Bhṛṅgarāja drava</i> (Pl.) | : | Q.S. for mardana |

Method:

Powder the *Añjana*, add quantity sufficient *bhṛṅgarāja drava* (svarasa) and grind till the contents get dried completely.

9. *Sauvīrāñjana* has the following attributes:-

9.1 Properties and Actions:

Rasa	-	Tikta, Kaṣāya, Kaṭu
Guṇa	-	Snigdha
Vīrya	-	Śīta
Vipāka	-	Madhura
Karma	-	Grāhī, Vraṇa Śodhana, Ropaṇa, Rajorodhaka

9.2 Therapeutic Uses

9.2.1. Śuddha *Sauvīrāñjana* (External): Netra Roga (diseases of eye)

9.2.2. Bhasma of *Sauvīrāñjana*: Raktapitta (bleeding disorder); viṣa doṣa (disorders due to poison); Hikkā (hiccup); rajorodha (obstruction of menstrual flow); Raktapradara* (menorrhagia or metrorrhagia or both)

10. Dose: 60-125 mg of the *bhasma*

***Precaution:** It should not be used for more than three days in Raktapradara.

11. Important Formulations: Irimedādi taila (for external use), Nayanāmṛtāñjana (for external use).

SVARṆA (Gold metal)

1. **Definition:** *Svarṇa* (Au) is a yellow metal available in the form of ingots.

2. **Synonyms:**

2.1 **Saṁskṛta** : *Hāṭaka, Hema, Kanaka, Suvarṇa, Hiraṇya, Kañcana*

2.2 **Names in other Languages:**

Bangali	-	Sonā
English	-	Gold
Gujarati	-	Sonu
Hindi	-	Sonā
Latin	-	Aurum
Marathi	-	Sone
Telugu	-	Bangāram

3. **Broad Classification:** Metal

4. **Origin and occurrence:** *Svarṇa* is present in the earth's crust and in sea water to the extent of about 4 parts in a hundred million. Most of the *Svarṇa* that occurs in the earth's crust is in the native state. It occurs in 2 types of deposits; (i) in hydrothermal veins and (ii) in placers. *Svarṇa* of hydrothermal origin occurs mostly in quartz veins, commonly with pyrite and other sulphides, and gold-silver telluride. The primary deposits of *Svarṇa* occur in intrusive rocks having composition of diorite, quartz-diorite and granites and their metamorphic equivalents. Placers of *Svarṇa* occur as rounded or flattened grains and nuggets, in many cases in association with other heavy and resistant minerals. Large quantity of *Svarṇa* is obtained from sulphides, with which it is probably mechanically mixed.

Svarṇa occurs very widely diffused in nature, chiefly in the free state, but invariably alloyed with some proportion of *Rajata* or *Tamra*, and occasionally with bismuth, mercury and other metals. Native *Svarṇa* has been known to contain as much as 99.80% gold (Au), but commonly contains 85-95% Au, the balance being usually silver for the most part. The name **electrum** is applied to natural Gold with 20% or more Silver.

The purity or fineness of *Svarṇa* is expressed in carats or parts per thousand (1000). Gold containing 999.9 parts per thousand (i.e. 99.99 % Au) is termed as 24 carat Gold. The 22 carat Gold (the standard for Gold coin and jewellery) contains 916.6 parts of gold and 83.4 parts of copper in thousand. That means, 22 carat Gold contains 91.66 % Au and 8.34 % Cu.

In India, the deposits of primary *Svarṇa* occur mainly in Hassan and Chitradurga districts in Karnataka, Chigargunta (Chittor district) in Andhra Pradesh and Kozhikode and Cannore districts in Kerala. Occurrences of *Svarṇa* have

recently been discovered in the states of Rajasthan and Madhya Pradesh. Main producer of *Svarṇa* in country today are Hutti Gold Mines Co. Ltd. (HGML) and Hindustan Copper Ltd. (HCL) as by-product. It is available in market in the form of ingots.

5. **Physical properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix –1).

Nature	: Granular, dendrites and nuggets
Colour	: Golden yellow
Streak	: Bright yellow
Cleavage	: None
Fracture	: Hackly
Lustre	: Metallic
Tenacity	: Very malleable and ductile
Transparency	: Opaque
Hardness	: 2.5 to 3.0 (readily scratched by knife)
Sp.Gr.	: 19.30; varies from 15.6 to 18.3 when contains alloying elements like Silver or Copper

6. **Chemical Properties:**

6.1 **Solubility:** Insoluble in any single acid (*hydrochloric acid, sulphuric acid or nitric acid*) but soluble in aqua-regia (HNO_3 : HCl , 1:3)

6.2 **Assay:** *Svarṇa* should contain not less than 99.99% Gold (Au) when analysed by Atomic Absorption Spectrometer (Appendix-3.2.6 & 3.2.10).

6.3 **Heavy metals and Arsenic:** In *Svarṇa* Mercury, Lead, Arsenic and Cadmium should be absent.

7. **Distinction from *Svarṇamākṣika* and *Vimala***

7.1 *Svarṇamākṣika* and *Vimala* both are brittle and soluble in *nitric acid* which is not in the case of *Svarṇa*.

7.2 *Vimala* has higher hardness (6-6.5) compared to other two.

7.3 The streak of *Svarṇa* is yellow while *Svarṇamākṣika* gives greenish black streak.

8. **Śodhana:** Shall not be used in formulations without subjecting it to śodhana.

9. *Svarṇa* is used in the form of *bhasma*, the details of which are given in the monograph of *bhasma*.

SVARNAMĀKŚIKA

(Copper Ore)

1. **Definition:** *Svarṇamākṣika* is a copper ore containing Chalcopyrite (CuFeS_2) mineral.

2. **Synonyms:**

2.1 **Saṁskṛta :** *Dhātumākṣika, Mākṣika, Hemamākṣika, Tāpya*

2.2 **Names in other Languages:**

English	-	Chalcopyrite, Copper ore
Gujarati	-	Mākṣika, Sonāmākhī
Hindi	-	Sonāmākhī, Sonāmakkhi,
Kannada	-	Dhātumākṣika
Malayalam	-	Makkirakallu
Marathi	-	Dagaḍī, Sonāmukhī
Tamil	-	Ponnimilai (S.F.I.)
Telugu	-	Mākṣīkamu, Svarṇamakhi
Urdu	-	Miss Sokhta (N.F.U.M.)

3. **Broad classification:** Sulphide

4. **Origin and occurrence:** *Svarṇamākṣika*, in ore form, occurs mainly in metamorphic rocks of pre-cambrian age. Occurrence of 100% pure *Svarṇamākṣika* in abundance is not common because it is always associated with host rock in the form of disseminations, streaks, stringers, patches, veins or lodes as fracture and cleavage fillings. *Svarṇamākṣika* generally occurs in association with pyrrhotite, pyrite, sphalerite and galena minerals. Gold, Silver, Arsenic, Nickel and Cobalt in trace amounts, are always present in *Svarṇamākṣika*.

In India, large deposits of *Svarṇamākṣika* occur mainly in Khetri, Distt. Jhunjhunu in Rajasthan, Malanjkhand, Distt. Balagaht in Madhya Pradesh and Ghatsheela, Distt. Singhbhum in Jharkhand. Mining of *Svarṇamākṣika* from these 3 areas is carried out by Hindustan Copper Limited (A Govt. of India Enterprise). More than 90% production of this ore in the country comes from these areas only. Small deposits, however, occur in Chitradurga and Hassan in Karnataka, Kurnool and Guntur in Andhra Pradesh and Rangpo in Sikkim.

5. **Physical Properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix 1).

Nature	:	Massive, smooth
Colour	:	Golden yellow
Streak	:	Greenish black
Fracture	:	Uneven
Lustre	:	Metallic
Tenacity	:	Brittle

Transparency	: Opaque
Hardness	: 3 to 4
Sp.Gr	: 3.4 to 3.7

6. Chemical Properties:

6.1 Charcoal Test: When heated on charcoal, a fragment of *Svarṇamākṣika* fuses to a black mass without swelling which is strongly magnetic, as felt by a horse-shoe magnet (Appendix-3.4.4).

6.2 Reaction with Acid: Take *nitric acid* in a test tube. Heat to boil for 5 minutes and cool to room temperature. Take 1 g of finely powdered sample in a dry test tube, add 10 ml of the *nitric acid* to it and heat. The solution becomes bluish black.

6.3 Assay:

6.3.1 *Svarṇamākṣika* in ore form should contain not less than 5% Copper (Cu) (Appendix-3.1.9 & 3.2.2).

6.3.2 *Svarṇamākṣika* in ore form should contain not less than 20% Iron and 12% Sulphur when analysed by gravimetric method (Appendix-3.1).

6.4 Heavy metals and Arsenic: *Svarṇamākṣika* in ore form should contain not more than the stated limits for the following: - Lead = 70 ppm, Arsenic = 1 ppm and Cadmium = 3 ppm (Appendix-3.2).

6.5 Other Elements: *Svarṇamākṣika* in ore form may contain the following within $\pm 20\%$ of the stated limits:- Gold = 0.70 ppm, Silver = 48 ppm and Zinc = 800 ppm (Appendix-3.1 & 3.2).

7. Distinction from Vimala

7.1 Golden yellow colour and softer than *Vimala* (pyrite), which has hardness 6-6.5.

7.2 *Svarṇamākṣika*: greenish black streak, *Vimala*: brownish black streak

7.3 Copper content in *Vimala* is negligible.

8. Śodhana: Shall not be used in formulations without subjecting it to śodhana.

9. *Svarṇamākṣika* is used in the form of *bhasma*, the details of which are given in the monograph of *bhasma*.

SVARṆAMĀKṢIKA -SĀNDRITA (Copper Concentrate)

1. **Definition:** *Svarṇamākṣika-Sāndrita* is a copper concentrate containing Chalcopyrite (CuFeS_2) mineral with minimum 12 % copper content. (*Svarṇamākṣika-Sāndrita*, herein after, is referred as *Sāndrita Svarṇamākṣika* in the rest of the monograph).
2. **Broad classification:** Sulphide
3. **Origin and occurrence:** There is no natural occurrence of *Sāndrita Svarṇamākṣika* in India or in the world. It is a processed material in the form of fine powder. Beneficiation is done by crushing and grinding of *Svarṇamākṣika* and subjecting its slurry to froth floatation. It is important to note that even after processing, it retains its overall mineralogy as well as other properties. The only difference is increase in copper content to more than 12 %. There is a little increase in the content of other major ingredients also. Like *Svarṇamākṣika*, it also contains trace but comparatively higher amount of Gold, Silver, Arsenic, Lead, Zinc, Nickel and Cobalt.

In India, large quantity of *Sāndrita Svarṇamākṣika* is produced by Hindusthan Copper Limited at Khetri in Rajasthan, Malanjkhand in Madhya Pradesh & Ghatsheela in Jharkhand.

3.1 Preparation of *Sāndrit Svarṇamākṣika*:

The *Sāndrita Svarṇamākṣika* is produced by crushing and grinding of *Svarṇamākṣika* ore lumps to 200 mesh size powder. Substantial amount of water (@ 2.5 M^3 per tonne of ore ground) is added during grinding of copper ore to make the material a slurry. This slurry is subjected to froth floatation process, during which pine oil (@ 28 g per tonne of ore ground) and sodium ethyl xanthate (@ 35 g per tonne of ore ground) are added to the floatation cells. The pine oil acts as frother whereas sodium ethyl xanthate as collector. This process enriches the copper content of the slurry just by discarding the gangue material from it. The enriched slurry, which comes out of floatation cells as froth, is dried through hot air driers. The dried fine powder of 200 mesh size is termed as **Concentrate** and the process is called beneficiation. The minor amount of pine oil and sodium ethyl xanthate, which was added during floatation process, will totally go away during further processing (i.e. *śodhana*) by the pharmacies. Hence, the material, which remains after *śodhana*, will be nothing but *Sāndrita Svarṇamākṣika* containing higher content of its ingredients.

4. **Physical Properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix 1).

Nature	:	Fine powder
Colour	:	Greenish black with yellow tinch
Lustre	:	Dull-metallic
Sp.Gr	:	3.8 to 4.1

5. **Chemical Properties:**

5.1 **Charcoal Test:** When heated on charcoal, *Sāndrita Svarṇamākṣika* fuses to a black mass which is strongly magnetic, as felt by a horse-shoe magnet (Appendix-3.4.4).

5.2 **Reaction with Acid:** Take *nitric acid* in a test tube. Heat to boil for 5 minutes and cool to room temperature. Take 1 g powder of *Sāndrita Svarṇamākṣika* in a dry test tube, add 10 ml of the *nitric acid* to it and heat. The solution becomes bluish black.

5.3 **Assay:**

5.3.1 *Sāndrita Svarṇamākṣika* should contain not less than 12% Copper (Cu) (Appendix-3.1.9 & 3.2.2).

5.3.2 *Sāndrita Svarṇamākṣika* should contain not less than 25% Iron and 28% Sulphur when analysed by gravimetric method (Appendix-3.1).

5.4 **Heavy metals and Arsenic:** *Sāndrita Svarṇamākṣika* should contain not more than the stated limits for the following: Arsenic = 100 ppm and Cadmium = 5 ppm (Appendix – 3.2).

5.5 **Other Elements:** *Sāndrita Svarṇamākṣika* may contain the following within $\pm 20\%$ of the stated limits:- Gold = 0.40 ppm, Silver = 50 ppm and Zinc = 0.20% (Appendix-3.1 & 3.2).

6. **Śodhana:** Shall not be used in formulations without subjecting it to śodhana.

7. *Sāndrita Svarṇamākṣika* is used in the form of *bhasma*, the details of which are given in the monograph of *bhasma*.

TĀMRA (Copper Metal)

1. **Definition:** *Tāmra* is the end product of the metallurgical process of Copper ore. It is available in the form of wires, sheets or rods of Copper which is produced by an electrolytic process.

2. **Synonyms:**

2.1 **Saṁskṛta :** *Śulvaka, Śulva, Sūrya, Sūryasakhā, Tāmraka, Ravi*

2.2 **Names in other Languages:**

Bangali	-	Tāmā
English	-	Copper
Gujarati	-	Trāmbu, Tāmbu
Hindi	-	Tāmbā
Kannada	-	Tāmbra
Latin	-	Cuprum
Malayalam	-	Chembu
Marathi	-	Tāmbe
Tamil	-	Chempu (S.F.I.)
Telugu	-	Rāgi
Urdu	-	Nuhas, Miss, Tāmba (N.F.U.M.)

3. **Broad Classification:** Metal

4. **Origin and occurrence:** *Tāmra*, in native form, occurs as irregular platy dendrites, crystals and compact mass and is most commonly associated with basic extrusive igneous rocks. Such occurrences are very limited. Electrolytically refined *Tāmra* is produced mainly in smelter/ refinery plants at Khetri in Rajasthan and Maubhandar-Ghatsheela in Jharkhand, where Copper ore occurs in abundance. Native *Tāmra* is comparatively less pure than electrolytically refined Copper, which contains 99.50% to 100% Cu.

Native *Tāmra* as well as electrolytically refined Copper generally contain trace amounts of Gold, Silver, Zinc, Arsenic, Iron, Bismuth and Antimony.

5. **Physical properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix –1).

Nature	:	Plates, wires or rods; can be bent by hand
Colour	:	Copper red
Streak	:	Copper red
Cleavage	:	None
Fracture	:	Hackly
Lustre	:	Metallic
Tenacity	:	Malleable
Transparency	:	Opaque

Hardness	:	2.5 to 3.0
Sp. Gr.	:	8 to 9

6. Chemical Properties:

- 6.1 **Reaction with acids:** Take about 5 g of finely powdered (150 mesh) *Tāmra* in a borosil test tube. Add 10 ml *nitric acid*. It gets completely dissolved in the acid giving a blue solution. Add an excess of *ammonia* to this blue solution. The colour of solution changes to deep azure blue.
- 6.2 **Assay:** *Tāmra* should contain not less than 99.5% Copper (Cu) (Appendix-3.1.9 & 3.2.2).
- 6.3 **Heavy metals and Arsenic:** *Tāmra* should not contain more than the stated limits for the following: - Lead = 5 ppm, Arsenic = 1 ppm and Cadmium = 5 ppm (Appendix-3.2).
- 6.4 **Other Elements:** May contain the following within $\pm 20\%$ of the stated limits:- Zinc = 25 ppm, Silver = 10 ppm and Gold = 135 ppb (Appendix-3.1 & 3.2).

7. **Śodhana:** Shall not be used in formulations without subjecting it to śodhana.

8. *Tāmra* is used in the form of *bhasma*, the details of which are given in the monograph of *bhasma*.

TAÑKAṆA (Borax)

1. **Definition:** *Tañkaṇa* is Borax mineral ($\text{Na}_2\text{B}_4\text{O}_7, 10 \text{ H}_2\text{O}$), also known as Tincal.
2. **Synonyms:**
 - 2.1 **Saṁskṛta** : *Tañkaṇaka, Taṇga, Taṇka, Saubhāgya*
 - 2.2 **Names in other Languages:**

Bangali	-	Sohāgā
English	-	Borax, Tincal
Gujarati	-	Tañkana Khāra, Khadiyo Khāra
Hindi	-	Suhāgā
Kannad	-	Biligāra, Belgār
Malayalam	-	Pongaaram
Marathi	-	Tañkaṇa Khāra
Punjabi	-	Sohāgā
Tamil	-	Venkaram (S.F.I.)
Telugu	-	Veligāram
Urdu	-	Tankar, Suhaga (N.F.U.M.)
3. **Broad Classification:** Borax (Sodium borate)
4. **Origin and occurrence:** *Tañkaṇa* occurs as deposits from volcanic emanations (fumaroles), hot springs and in dried up shallow basins (Playa) or saline lakes. It occurs mostly in the waters of various saline lakes in the salt deposits that have been formed through evaporation of such lakes. The origin of *Tañkaṇa* involves simple concentration and evaporation, which is accompanied by some chemical and mineralogical transformations to give rise to *Tañkaṇa* (borax). An evaporite mineral, it occurs associated with halites, sulphates, carbonates and other borates like ulexite and colemanite.

Economically workable deposits of *Tañkaṇa* are not yet discovered in India, and the domestic need is met by imports of crude borates, which are refined to produce *Tañkaṇa* and boric acid. Small quantity of *Tañkaṇa*, since early times, however, was being obtained from salt lakes in Leh district of Jammu and Kashmir and Tibet, where it occurs today also. Non-exploitable occurrences of *Tañkaṇa* are known in Surendranagar district in Gujarat and Jaipur and Nagaur districts in Rajasthan.
5. **Physical properties** : (Definition / explanation of technical terms and methods of determination as given in Appendix –1).

Nature	:	Crystalline lumps
Colour	:	White
Streak	:	White
Cleavage	:	Poor

Fracture	:	Conchoidal
Lustre	:	Vitreous
Tenacity	:	Brittle
Transparency	:	Translucent
Hardness	:	2 to 2.5
Sp. Gr.	:	1.65 to 1.7
Taste	:	Sweetish alkaline

6. Optical properties.

Biaxial, Negative, with η_α , 1.447, η_β , 1.469 and η_γ , 1.472 (Appendix-2)

7. Chemical Properties:

7.1 Effect of Heat:

7.1.1 Heated on a burner flame using blowpipe, *Taṅkaṇa* bubbles up and fuses to a clear glassy bead.

7.1.2 It colours the flame yellow due to sodium and when moistened with sulphuric acid and alcohol, gives a green flame due to boron (Appendix-3.4.3).

7.2 Reaction with acids:

7.2.1 With hydrochloric acid - gives yellow colour solution in cold condition and on boiling dissolves completely.

7.2.2 With sulphuric acid - gives colourless solution in cold condition and on boiling dissolves completely.

7.3 Solubility in water: *Taṅkaṇa* is completely soluble in *purified water* producing an alkaline solution as tested by a red litmus paper turning blue.

7.4 Assay:

7.4.1 *Taṅkaṇa* should contain not less than 35% B_2O_3 (Boron trioxide) (Appendix-3.2.14).

7.4.2 *Taṅkaṇa* should contain not less than 15% Sodium (Na) (Appendix-3.2.13).

7.5 Heavy metals and Arsenic: *Taṅkaṇa* should not contain more than the stated limits for the following: - Arsenic = 5 ppm and Cadmium = 4 ppm (Appendix-3.2).

8. Śodhana: Shall not be used in formulations without subjecting it to śodhana.

8.1 Śodhana: [Ref: AFI-Part-I; Appendix-II, Śodhana-19]

Method:

Prepare coarse powder of *Tarikaṇa* and fry over heat source, collect when completely dehydrated.

9. *Tarikaṇa* has the following attributes:

9.1 Properties and Actions:

Rasa	-	Kaṭu
Guṇa	-	Rūkṣa, Uṣṇa, Tīkṣṇa, Sāraka
Vīrya	-	Uṣṇa
Vipāka	-	Kaṭu
Karma	-	Hṛdya, Balya, Sāraka, Kapha nissāraka, Dīpana, Strī puṣpajanana, Mūḍhagarbhapravartaka

9.2 Therapeutic Uses: Kāsa (cough); Śvāsa (Asthma); Vāta roga (diseases due to Vāta doṣa); Sthāvara viṣa (poisoning by plant or mineral); Ādhmāna (flatulence with gurgling sound); Vraṇa (wound/ulcer)

10. Dose: 125 - 250 mg

11. Important Formulations: Ānandabhairava rasa, Candrāmṛta rasa, Icchābhedī rasa, Saubhāgya vaṭī, Tribhuvanakīrti rasa.

TUTTHA (Copper Sulphate)

1. **Definition:** *Tuttha* is copper sulphate ($\text{Cu SO}_4, 5\text{H}_2\text{O}$), also known as blue vitriol, copper vitriol, blue stone or chalcanthite mineral.

2. **Synonyms:**

2.1 **Saṁskṛta** : *Tutthaka*

2.2 **Names in other Languages:**

Bangali	-	Tunte, Tuntiyā
English	-	Copper Sulphate, Blue vitriol
Gujarati	-	Morathuthu
Hindi	-	Nīlā Thothā, Tūtiā
Kannada	-	Mayuruthutha
Malayalam	-	Mayilthuththam
Marathi	-	Moracūda
Tamil	-	Mayil thuththam, Turken (S.F.I.)
Telugu	-	Mailu tuttham, Melatutu
Urdu	-	Tutia, Kabood (N.F.U.M.)

3. **Broad Classification:** Hydrous cupric sulphate

4. **Origin and occurrence:** *Tuttha* occurs with other hydrated sulphates of copper and iron in the oxidized form near surface zones of copper sulphide ore deposits. It is found generally deposited with mine *purified waters*, often on the walls of abandoned mine workings. Also, it is found in the zones of weathering of Copper lodes.

In India, natural occurrence of *Tuttha*, in abundance, is uncommon. A little amount of *Tuttha* can be seen near copper mines in Rajasthan, Madhya Pradesh and Jharkhand. Mostly, commercially manufactured *Tuttha* as a chemical is used for Ayurvedic formulations in the country.

5. **Physical properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix –1).

Nature	:	Crystalline lumps
Colour	:	Berlin or sky blue
Streak	:	Colourless
Cleavage	:	Poor
Fracture	:	Conchoidal
Lustre	:	Vitreous
Tenacity	:	Brittle
Transparency	:	Translucent
Hardness	:	2 to 2.5
Sp. Gr.	:	2.12 to 2.30

6. Chemical Properties:

6.1 Effect of Heat:

6.1.1 On heating, partially evaporates giving brownish mass.

6.1.2 Heating with *sodium carbonate* (Na_2CO_3) gives black fused mass.

6.1.3 Heat on charcoal with *sodium carbonate* (Na_2CO_3) and carbon, it yields metallic copper as observed by its copper red colour.

6.1.4 Heat in closed tube, *Tuttha* gives off water, observed as droplets on the upper internal wall of the tube (Appendix-3.4.5).

6.2 **Solubility in purified water:** Take about 10 g accurately weighed fine (150 mesh) powder of *Tuttha* in 250 ml beaker. Add 50 ml *purified water* to it. Stir the solution till *Tuttha* powder stops dissolving. Put the beaker in sun light till the solution gets completely dried up. Weigh the residue, if any. It should not be more than 10% of the initial weight of the sample. That is, solubility of *Tuttha* in *purified water* should not be less than 90%.

6.3 **Assay:** *Tuttha* should contain not less than 20% Copper (Appendix-3.1.9 & 3.2.2).

6.4 *Tuttha* should contain not less than 15% Sulphur and not less than 50% SO_4 (Appendix-3.1 & 3.3).

6.5 **Heavy metals and Arsenic:** *Tuttha* should not contain more than the stated limits for the following: - Lead = 226 ppm, Arsenic = 4 ppm and Cadmium = 97 ppm (Appendix-3.2).

6.6 **Other elements:** May contain the following within $\pm 20\%$ of the stated limits:- Iron 4 % when analysed by gravimetric method (Appendix-3.1.4).

7. Śodhana - Shall not be used in formulations without subjecting it to śodhana.

7.1 **Śodhana:** [Ref: AFI-Part-I; Appendix-II, Śodhana-21]

i) <i>Tuttha</i>	:	1 Part
ii) Rakta Candana kvātha	[Ht.Wd]	: Q.S. for bhāvanā
iii) Mañjiṣṭhā kvātha	[Rt.]	: Q.S. for bhāvanā
iv) Varā [Triphalā] kvātha	[P.]	: Q.S. for bhāvanā

Method:

Powder *Tuttha*, add quantity sufficient *Rakta Candana Kvātha* and grind till complete moisture gets evaporated. Repeat the process for seven times. The process of levigation is to be repeated in all other liquid media i.e. *Mañjiṣṭhā Kvātha* and *Varā Kvātha* individually for seven times each.

8. **Tuttha** has the following attributes:

8.1 Properties and Actions:

Rasa	-	Kaṭu, Kaṣāya, Madhura
Guṇa	-	Laghu, Sara
Vīrya	-	Uṣṇa, Śīta
Vipāka	-	Kaṭu
Karma	-	Kaphapittahara, Lekhana, Bhedana, Balya, Tridoṣaghna, Rasāyana, Rucikara, Vāmaka, Varṇya, Garaviṣahara, Śūlaghna, Cakṣuṣya, Aśmarīhara, Kaṇḍūghna, Kṣārakarmakara, Arśoghna, Kṛmighna

8.2. Therapeutic Uses: Kṛmi (helminthiasis/worm infestation); Prameha (increased frequency and turbidity of urine); Medoroga (obesity); Śūla (pain/colic); Kuṣṭha (diseases of the skin); Śvāsa (Asthma); Amlapitta (hyperacidity); Tvak roga (skin disease); Śvitra (Leucoderma /Vitiligo); Arśa (piles); Vraṇa (ulcer/wound); Nāḍī Vraṇa (sinus); Netra roga (diseases of eyes); Duṣṭa vraṇa (non-healing ulcer)

9. **Dose:** 15 - 30 mg

10. **Important Formulations:** Jātyādi taila, Nityānanda rasa, Jātyādi ghṛta, Mahā viṣagarbha taila, Kāsīsādi ghṛta

VAIKRĀNTA

(Tourmaline)

1. **Definition:** *Vaikrānta* is Tourmaline, sodium aluminium borosilicate of the formula $[(Ca, Na)X(Mg, Al_6)X\{B_3 Al_{12} Si_6 X(O, OH)_{30}\}]$

2. **Synonyms:**

2.1 **Names in other Languages:**

Bangali	-	Cūniviśeṣa
English	-	Tourmaline
Gujarati	-	Taramari
Hindi	-	Turamuri
Marathi	-	Turamali, Toramali
Telugu	-	Vaikrantamu

3. **Broad Classification:** Complex ring silicate of boron and aluminium.

4. **Origin and occurrence:** *Vaikrānta* occurs in granite pegatites, commonly in radial crystal form. It also occurs in metamorphic rocks, mostly in schists and gneisses. *Vaikrānta* is a common detrital heavy mineral in sedimentary rocks. *Vaikrānta* is a wide spread mineral and used also as a Gemstone.

In India, it occurs in igneous and metamorphic terrains of Rajasthan, Jharkhand, Bihar and Karnataka. In Rajasthan, it mainly occurs in Udaipur, Bhilwara, Ajmer and Rajsamand districts. Vaikranta may be found associated with topaz, spodumene, cassiterite, fluorite and apatite.

5. **Physical properties:** (Definition / explanation of technical terms and methods of determination as given in Appendix -1).

Nature	:	Crystalline prismatic
Colour	:	Black
Streak	:	Colourless
Cleavage	:	None, prismatic faces strongly striated vertically and crystals rounded to barrel shaped
Fracture	:	Uneven
Lustre	:	Vitreous
Tenacity	:	Brittle and often rather friable
Transparency	:	Translucent
Hardness	:	7 to 7.5
Sp. Gr.	:	3 to 3.2

6. **Optical properties:**

Uniaxial, negative, η_o 1.65 to 1.69, η_e 1.63 to 1.66, strong birefringence; dichroism present, as seen in parallel polarized light (uncrossed), with change in colour when a fragment is oriented at two positions, right angle to each other, by rotating the stage of microscope (Appendix-2).

7. Chemical Properties:

7.1 Effect of Heat:

7.1.1 Pyroelectricity- When heated at one end, *Vaikrānta* crystal attracts small bits of papers at the other end.

Heated before blowpipe, *Vaikrānta* swells up and does not fuse easily.

7.2 Reaction with acids: *Vaikrānta* does not decompose by any acid.

7.3 Assay:

7.3.1 *Vaikrānta* should contain not less than 6% B_2O_3 when analysed by ICPA method (Appendix-3.2.14).

7.3.2 *Vaikrānta* should contain not less than 12 % ferric oxide (Fe_2O_3), not less than 30% Alumina (Al_2O_3) and not less than 30% Silica (SiO_2) when analysed by gravimetric method (Appendix-3.1).

7.4 Heavy metals and Arsenic: *Vaikrānta* should not contain more than the stated limits for the following: - Lead = 11 ppm, Arsenic = 4 ppm and Cadmium = 2 ppm (Appendix-3.2).

8. Śodhana: Shall not be used in formulations without subjecting it to śodhana.

9. *Vaikrānta* is used in the form of *bhasma*, the details of which are given in the monograph of *bhasma*.

APPENDIX - 1

Physical Properties

Definitions / Explanations of Geological/ Technical
Terms (Terminology) used in Pharmacopoeial
Monographs and Methods of Determination

1. PHYSICAL PROPERTIES OF MINERALS AND METALS

(Definitions of Geological Terminology and Methods of Determination of Various Parameters)

1.1. NATURE

Being natural chemical compounds, minerals may occur in any aggregation state, though most of them are known to belong to solid crystalline substances. Amorphous minerals are scarce. As such, natural occurrence of minerals may be in the following forms:-

- i) **Crystalline** (columnar, bladed, fibrous and tabular etc.)
- ii) **Amorphous** (massive, earthy and resinous etc.)
- iii) **Opaque, transparent and translucent**
- iv) **Aggregate** (granular, incrustated, micaceous etc.)

1.1.1. State of Aggregation

Under favourable conditions, minerals assume a definite crystal form. The following crystal forms are known:-

- a. Crystallised:** A term denoting that the mineral occurs as well-developed crystals. Most of the beautiful mineral specimens in museums are of crystallized minerals.
- b. Crystalline:** A term denoting that no definite crystals are developed, but that a confused aggregate of imperfect crystal grains have formed interfering with one another during their growth.
- c. Crypto- crystalline:** A term denoting that the mineral possesses traces of crystalline structure.
- d. Amorphous:** A term used to describe the complete absence of crystalline structure, a condition common in natural rock glasses, but rare in minerals.

1.1.2. Crystal Habit

The development of an individual crystal or an aggregate of crystals to produce a particular external shape is described as its Habit and this depends upon the conditions during formation.

A. Individual crystals

- a. Acicular** : Fine needle like crystals
- b. Bladed** : Shaped like a knife blade or lath like

- c. **Fibrous** : Consisting of fine thread like strands
- d. **Foliated** : Consisting of thin and separate lamellae or leaves as is shown by mica group of minerals
- e. **Lamellar** : Consisting of separate plates or leaves as in wollastonite
- f. **Prismatic** : Elongation of crystals in one direction
- g. **Reticulated** : Crystal in a cross-mesh pattern, like a net
- h. **Scaly** : In small plates
- i. **Tabular** : Broad, flat, thin crystals

B. Crystal Aggregates

There may be aggregates of the crystals of which individuals can be seen with the naked eye or massive aggregates of minerals in which individual crystals are too small to be seen with the naked eye.

- a. **Botryoidal** : Spherical aggregates resembling a bunch of grapes
- b. **Columnar** : Massive aggregations in slender columns
- c. **Granular** : Coarse or fine grains
- d. **Lenticular** : Flattened balls or pellets shown by many concretionary and nodular minerals
- e. **Radiating** or : Fibres arranged around a central point
divergent
- f. **Lump** : An uneven mass / piece of mineral / ore / rock

1.2. COLOUR

A mineral gives a constant distinctive colour, when observed on freshly broken surface. Though this property is not clear in many minerals, commercial minerals, by and large, are distinguished by their typical colour.

1.3. STREAK

The fine powder of a mineral shows more constant colouration than the same mineral in a massive specimen. This phenomenon is used for identification of a mineral by rubbing the mineral on a rough surface. A white unglazed porcelain plate commonly known as **streak plate** is generally used to see the colour of the powder of a mineral. Streak is a more reliable distinguishing feature of minerals with a semi-metallic and sub-metallic lustre.

Method of determination

Take sample in question and a streak plate then draw a line or rub across the white surface of the streak plate with the sample. Now observe the colour of the powder left by the trail. This colour is the streak of that particular mineral.

Tools: Streak Plate

1.4. CLEAVAGE OR PARTING

Cleavage or parting is the tendency of minerals to split along certain definite planes. The cleavage plane is closely related to crystalline form and internal atomic structure and therefore is generally parallel to crystal faces. Minerals may show several cleavages, which are described by stating the crystallographic directions of each cleavage and also the degree of perfection of each cleavage plane. Cleavage may be described in order of quality as under:

- a. Perfect or eminent** : Cleavage planes are seen perfectly in the minerals.
- b. Good or distinct** : Cleavage planes can be seen with little effort.
- c. Poor or indistinct** : Cleavage planes indistinctly visible.

Method of determination

Take the mineral and break it with a hammer gently. If the mineral separates along parallel planes each time when it is repeatedly broken, it is said to possess cleavage. Observe the quality of the cleavage as defined above. Observe some minute step-like planes or a wavy pattern on the surface of the mineral. Smooth parallel cracks or directional cracks are indication of cleavage direction.

Tools: Small (about ½ kg) hammer.

1.5. FRACTURE

The character of the fracture displayed on the broken or chipped surfaces of a mineral is an important property. The fracture surface is not the smooth surface of a cleavage plane but is an irregular surface, usually totally independent of cleavage. The types of fractures, known are given here.

- a. Conchoidal** : The mineral breaks with a curved concave or convex fracture. This often shows concentric and gradually diminishing undulations towards the point of impact, somewhat resemble the growth lines on a seashell.
- b. Even** : The fractured surface is flat.
- c. Uneven** : The fractured surface is rough by reason of minute elevations and depressions. Most minerals have an uneven fracture.
- d. Hackly** : The broken edge shows sharp and jagged projections / elevations like serrations.
- e. Earthy** : The dull fractured surface of chalk or clay minerals.

Method of determination

Take the mineral and break it with hammer in two pieces in such a way that it does not get shattered. Observe the broken surface (other than the cleavage plane/direction) and decide the type of fracture as defined above.

Tools: Small (about ½ kg) hammer.

1.6. LUSTRE

Lustre is one of the most regular and easily observable properties of a mineral. As a rule, a mineral reveals, at first glance, its lustre which is produced by the light reflected or refracted from the faces of crystals, cleavage planes and from freshly fractured faces of the mineral. Lustre is directly dependent on the light reflected from the surface.

Splendent : reflects objects distinctly like a mirror.

Shining : objects are reflected indistinctly

Dull : when the surface has no reflection or refraction

Various types of lustre are:

- a. **Metallic** : This is the ordinary lustre of metals. When feebly displayed, this type of lustre is termed *sub-metallic* and when not displayed at all, is termed as *dull*. Based on the intensity and degree of reflection /refraction, metallic lustre is termed as Metallic, Sub-Metallic, Dull and Non-Metallic.
- b. **Vitreous** : The lustre of broken glass. When less well developed, it is termed *sub-vitreous* and when not developed at all is *dull*.
- c. **Resinous** : The lustre of resin.
- d. **Pearly** : The lustre of Pearl. It is shown by the surfaces parallel to which the mineral is separated in to thin plates, similar to the condition of a pile of thin glass sheets such as cover glasses on microscopic slides.
- e. **Adamantine** : The lustre of Diamond.
- f. **Silky** : The lustre of silk. This lustre is peculiar to minerals possessing a fibrous structure.
- g. **Iridescence** : Play of colours of rainbow, as those formed in soap bubbles due to interference of light waves.

Method of determination

Observe the quality of natural light reflected on the faces of crystals, cleavage planes or fresh fracture of a mineral then decide the type of lustre as defined above.

Tools: Visual observation

1.7. TENACITY

This is a measure of how a mineral deforms when it is crushed or bent. In fact, tenacity or tensile strength is the resistance that a mineral offers to mechanical deformation. In other words, it is the resistance that the atoms or ions of a substance offer to being subjected to processes that tend to cause bending, breaking, crushing or cutting. Tenacity is termed as follows:-

- a. Sectile** : The mineral can be cut with a knife and the resulting slice breaks up under a hammer.
- b. Malleable** : A slice cut from the mineral/metal can be hammered into thin flat sheets.
- c. Brittle** : The mineral crumbles or shatters easily.
- d. Flexible** : The mineral or thin plates or laminae of the mineral can be bent, remains bent and does not return to its original position even if that pressure is removed.
- e. Elastic** : The mineral or thin plates or laminae of the mineral can be bent and returns to its original position after the pressure is removed.
- f. Ductile** : The mineral can be drawn out in to thin wires.

Method of determination

Take a hammer and hit the substance under question. Repeat the process several times till the substance breaks into pieces, this will change its shape, either will be bent or will be crushed. Observe the type of deformation (Tenacity) as defined above.

Tools: Small (about ½ kg) hammer.

1.8. LIGHT TRANSMISSION (TRANSPARENCY)

Transparency is a property of the substance to transmit light. In other words, the ability of a substance, to allow light to pass through it, is called transparency (Diaphaneity). Based on their capability and varying degrees of Transparency, the materials are said:

Transparent i.e. materials capable of transmitting light and through which an object can be seen easily with its sharp, clear and distinct outlines.

Translucent i.e. materials capable of transmitting light but through which an object cannot be seen, except an outline, generally distorted and blurred.

Opaque i.e. materials that are incapable of transmitting light.

Method of determination

Take the sample and observe whether one can see through it or not. Then decide the degree of transparency as defined above.

Tools: Visual observation

1.9. MAGNETISM

A few minerals / metals, in their natural state, are capable of being attracted by a hand magnet. They are called magnetic. In other words, if a mineral / metal gets attracted by a horse-shoe magnet or deflects the needle of a compass, it is said to possess magnetism. A substance may be strongly magnetic, weakly magnetic or non-magnetic.

Method of determination

There are two methods to know whether a substance is magnetic.

1. Take a simple horse-shoe magnet. Bring the mineral near both the ends of magnet and feel whether the mineral is attracted by the magnet or vice-versa. If attraction is felt, the mineral is said to be magnetic.
2. Take a compass. Bring the sample under question near the compass. If the needle of the compass deflects due to placement of the sample around the compass, the sample is said to be magnetic.

Feel the degree of magnetism of the substance and decide whether it is non-magnetic (no attraction at all), weakly magnetic (little attraction felt) and strongly magnetic (strong attraction felt).

Tools: Simple horse-shoe magnet or Compass

Horse Shoe Magnet: A horse shoe magnet is a magnetized small iron bar shaped as horse shoe. This has a property of attracting the substances possessing magnetism.

Compass: A compass is usually a rectangular (7.5 cm X 7.5 cm) or circular (8.5 cm diameter) small box having about 2 cm height with a glass cover on it. A magnetized needle is pivoted at the centre inside the box in such a way that it rotates freely in all directions. The compass also has a dial marked on it and graduated from 0° to 360° with indication of directions (i.e. 0° - North, 90° - East, 180° - South and 270° - West). The needle always indicates North - South direction, when it is at rest. To identify North pole of the needle that end indicating north is usually painted in different colour. The magnetic needle shows deflection towards the substances possessing magnetism, when brought around the compass.

1.10. HARDNESS

Hardness of a mineral is its resistance to scratching. It is a relative parameter. In mineralogy, relative hardness is always determined by using a set of minerals known as the **Moh's Scale of Hardness**. This scale consists of 10 reference minerals, each of which is assigned a number in order of increasing hardness from 1 (the lowest hardness, that of Talc) to 10 (the highest hardness, that of Diamond). The Moh's Scale of Hardness, with reference minerals, is given here.

Moh's Scale of Hardness

Hardness	Reference Mineral
1	Talc
2	Gypsum
3	Calcite
4	Fluorite
5	Apatite
6	Orthoclase
7	Quartz
8	Topaz
9	Corundum
10	Diamond

Method of determination

Take the mineral and select a smooth/clear surface. Scratch this smooth surface firmly with sharp edge of a reference mineral, specified in Moh's Scale of Hardness. Observe, whether this reference mineral can scratch the mineral under question. If not, take another reference mineral with higher hardness and observe the scratch again. Repeat the scratching process with reference minerals in increasing order of hardness, one by one, to determine nearer to correct hardness of the mineral under question.

Obviously, the substance, which can be scratched by a particular reference mineral (say-A) of known hardness will have lower hardness than the reference mineral-A, but will have higher hardness than the reference mineral (say-B), which has the hardness just less by one than that of reference mineral-A. Exact hardness of a mineral in ore form, of course, can not be determined because of its association with enclosing rock mass. However, nearer to accurate hardness is possible to be determined by identifying correct mineral surface and precise observation of the scratch on it by the reference mineral.

Tools: Set of reference minerals of Moh's Scale of Hardness (Reference minerals can be obtained from scientific stores dealing with geological instruments).

Important

1. Always start scratching with softer reference mineral and proceed upward one by one with reference mineral until just a visible scratch is seen.
2. Examine the scratch with a hand lens to ensure that it is a scratch and not the powder form the reference mineral. If it is a scratch, rubbing would not make it disappear, whereas if only a streak, it can be rubbed off.

1.11. SPECIFIC GRAVITY (DENSITY)

Specific gravity is the relative weight of a mineral compared to that of the weight of an equal volume of *purified water*. The weight of an equal volume of *purified water* is the same as the loss of weight of the mineral in *purified water*. Specific gravity is calculated by dividing the weight of the mineral in air by the loss of weight in *purified water*. The specific gravity of natural minerals is known to vary from 0.8 to 21.

Method of determination

There are several methods of determining specific gravity namely (1) By normal chemical balance (2) By Jolly's spring balance (3) By Walker's steelyard balance (4) By using pycnometer and (5) By using liquids of high density. The first method, which is quite simple, is being dealt with here.

Determination of specific gravity with the chemical balance :

Weigh accurately a small piece of mineral under question in air on a good, non-digital chemical balance of sensitivity 0.001g and record the weight (w_1). Then put a beaker half filled with *purified water* on a wooden bridge placed over the scale pan of the balance. Suspend the mineral by a horse-hair or a silk thread from one arm of the balance in the beaker filled with *purified water*. Now, weigh the mineral, immersed in *purified water* and record the weight (w_2).

The specific gravity of the mineral is determined by the formula:

$$\text{Specific Gravity} = \frac{\text{Weight of mineral in air } (w_1)}{\text{Loss of weight of mineral in } \textit{purified water} (w_1 - w_2)}$$

Tools: Chemical balance of 0.001 g sensitivity, beaker, wooden bridge, horse-hair or silk thread and *purified water*.

Geological Survey of India, western region, Jaipur has a specific gravity measuring kit, which calculates the specific gravity and gives its value straightway.

1.12. FLUORESCENCE

This is the property of substances, which emit light when subjected to irradiation with ultra-violet (UV), cathode or other short wave rays. Such luminescence remains only till the substance is kept under irradiation. It is a characteristic feature of some minerals.

Ultra-violet radiation has a range of wavelength from 400 nm to 200 nm. The range from 200 nm to 300 nm is called short wave (or far UV rays) and from 300 to 400 nm is called long wave (or near UV rays). Short wave UV lamp has been used in present determinations.

Method of determination

Place the sample in dark viewing cabinet carrying the UV source of radiation, irradiate for about 5 minutes. Then observe if there is any fluorescence visible. Turn the sample in different directions with observation. The sample is positive, if

under these conditions a bright colour different from the original colour of sample develops under irradiation and disappears if source of irradiation is removed.

Tools: Ultra-violet (UV) lamp of 200 to 400 nm.

1.13. XRD ANALYSIS

X - ray diffraction is one of the methods which can be employed to identify the crystalline matters such as minerals / metals, and inorganic / organic compounds. It is more useful in mixture or intergrowth of minerals including species identification by identifying its crystal structure and cell size.

Principle of X-Ray Diffraction

A beam of X - rays when strike a crystalline material or mineral, it causes electrons in its path to vibrate and scatter. Such X - rays when reinforce each other, the process is called diffraction. The diffracted X - rays strike equally spaced parallel rows of identical atoms or planes and behave as if they have been reflected from planes with in a crystal. Diffraction takes place from parallel (atomic) planes only, if they satisfy certain conditions simplified in Bragg's equation / law viz;

$$n\lambda = 2d \sin \theta$$

The diffraction effect is not from a single or a few such atomic planes but from almost infinite number of planes each reinforcing and contributing to increase intensity (of a particular plane or face) for recording.

The X - rays are collimated and allowed to fall on the powdered sample. A goniometer and a detector are placed in the diffracted path of the X - rays synchronized to measure the angle and detect the signals simultaneously. The signal (counts per second) is processed electronically and converted to digital mode on panel and simultaneously move the recorder pen to produce a chart / diffractogram in a synchronized chart drive. Each face of a crystal thus would be represented by a peak. The diffractometer would provide a recorded history of 2 *Theta* angles vis-à-vis the peaks (faces of crystals) as per their atomic configuration. Alternatively, the whole data can be stored in a computer and can be conveniently retrieved later.

Each mineral has its characteristic atomic configuration and thus a characteristic set of faces/peaks. Most of the minerals with a few exceptions have unique 'd' spacings and could be interpreted and identified by using certain parameters and comparison with published standard data cards (ICDD Cards or International Center for Diffraction Data Cards) which are used as reference patterns.

Functions of X'Pert Pro XRD Machine

X' pert Pro XRD machine works on the same principle as earlier XRD machines, where satisfaction of Bragg's law is necessary for identification. This is an advanced modular purpose diffractometer. All its functions are controlled by softwares with the help of a computer. It incorporates modular hardware for full flexibility and performance for routine and in depth research investigations.

X' Pert Pro has the latest innovative X' celerator detector with Real Time Multiple Strip (RTMS) technology which results in reducing the time of scanning of samples considerably. Detection of signals directly ensures efficiency and reliability.

A search match programme allows searching of peaks using 'Peak Search' option which leads to a list of a number of probable minerals of diverse composition depending upon the scoring / matching rate.

Procedure of X-Ray Analysis

Powder the sample approximately upto (–) 200 mesh size and load the sample in a sample holder provided with the machine. Switch 'ON' the X' Pert Pro machine and select the X'Pert Pro Data Collector Programme followed by increasing the current and voltage to the X-ray tube to the desired level and select the programme. Name the folder & file of the sample for identification then start Scanning as per the programme. Get out of X' Pert Pro Data Collector Programme and go to X'pert Pro High Score Programme select the peaks and go to analysis & execute search match. Pick up the right mineral/ compound based on scoring & matching of peaks.

APPENDIX - 2

Optical Properties

Definitions and Methods of Determination of
Different Optical Parameters

2. OPTICAL PROPERTIES OF MINERALS AND METALS **(Definitions and Method of Determination)**

Crystalline substances can be readily and specifically identified from their optical crystallographic properties, which can be determined within limits by means of the polarizing microscope. The identification involves microscopical crystallographic observations of optical phenomena and measurements of physical constants.

2.1. Apparatus

Polarizing microscope fitted with polarizing prisms below and above a rotating, graduated circular stage and with accessories (Bertrand lens or pinhole eye-piece, first order red or quartz wedge compensators for observations of interference figures, optic sign and sign of elongation). Refractometers for measuring refractive indices of liquids at 20°C from 1.300-1.840 with accuracy of ± 0.0005 , and for periodical checking of the indices in case permanent set of liquids are used (Please see Note below).

2.2. Reagents

Immersion Media: Ideally, immersion media, which are to be used for refractive index determination, should have the same color and intensity of color as the substance being examined. The liquids should be chemically stable. Their refractive indices should not vary perceptibly with ordinary changes of temperature with the exception of the special liquids used in index-variation methods. A permanent set of liquids covering the range 1.420 to 1.790 in 0.005 intervals made with the following mixtures is very useful for inorganic and organic drug substances:

2.3. Mixtures

	np
A. <i>n</i> -Decane and mineral oil	1.420 to 1.465
B. Light mineral oil and 1-chloronaphthalene	1.470 to 1.630
C. 1-Chloronaphthalene and methylene iodide	1.635 to 1.735
D. Methylene iodide and sulphur	1.740 to 1.790

(Note: Index of refraction liquids are also commercially available. One such set of liquids with a range of 1.400 to 1.700, in increments of 0.002 or 0.004, is the Cargille immersion oils, obtainable from R.P. Cargille Laboratories, Inc. Cedar Grove, N.J. (USA) or through the McCrone Research Associates, Chicago (USA).)

Substances, which are soluble in these liquids, will require preparation of a special set of liquids.

2.4. Refractive Index

2.4.1. Definition:

The refractive Index of a medium is defined as the ratio of the velocity of light in the medium to that in vacuo. It varies with wavelength but the variation is usually small for transparent minerals, so refractive indices for white light are usually quoted.

2.4.2. Principle

A non-opaque solid substance, when immersed in a liquid of same refractive index (R.I.) as that of non-opaque solid, becomes practically invisible in that liquid. This is because of the fact that the light passing from the liquid in to the solid and from solid back in to the liquid, is not refracted. The edges of the solid substance, as such, are not seen simply because the whole liquid-solid mixture acts as a homogeneous medium in its effect on light due to same R.I.

For the determination of the refractive indices, the crystals or crystal fragments of a given substance are successively suspended in immersion liquids of known refractive indices, advantage being taken of the fact that the greater the difference between the indices of refraction of crystals and liquids, the more prominently the one will stand out in bold relief from the other. By repeatedly mounting such crystals in oils of successively lower or higher index, it will be found that ultimately the zone of contact of crystal and liquid becomes practically invisible, therefore demonstrating that the refractive index of the liquid and solid has been matched. In the case of substances crystallizing in the isometric (cubic) system, there is only one refractive index, designated by the symbol η . Such substances are not doubly refractive when examined with crossed nicols. Substances crystallizing in other systems namely the hexagonal, tetragonal, monoclinic, triclinic, orthorhombic systems, in the ideal cases, have more than one measurable refractive index. In the case of uniaxial substances such as those crystallizing in the hexagonal and tetragonal systems, two significant indices can be determined, designated η_e and η_w . The indices of refraction in the monoclinic, triclinic and orthorhombic systems in the ideal cases are three in number and are designated as η_α , η_β and η_γ . The term η_i designates a common intermediate index other than β .

For compliance with monograph requirement, one index, η , of the Isometric system, two indices, η_e and η_w in the anisotropic, uniaxial system and three indices η_α , η_β and η_γ of the anisotropic, biaxial system, should match with the index of the selected liquid of known R.I.

2.4.3. Method of Determination of R.I. for

- a) *Isotropic*,
- b) *Anisotropic- uniaxial* and
- c) *Anisotropic-biaxial*

This method is known as **immersion method**.

Use a polarizing microscope with magnification power up to 400x. Adjust it to give orthoscopic illumination.

Principle: The method of confirming the R.I. prescribed in a monograph, so that compliance can be ascertained, is by observing the '*Becke Line*', which is a sharp, bright line at the edge of crystal fragment, mounted in a selected medium. The Becke Line can be made to move in and out of a crystal fragment that is in clear focus, by raising or lowering the focus. This is achieved by raising the microscope tubes, (or by lowering the stage in certain models), and by lowering the tube, (or by raising the stage) respectively for raising and lowering the focus, from a position of clear focus. If by raising the focus, the Becke Line moves *inwards* and *into* the crystal fragment making its centre bright, the fragment has a higher index than the surrounding medium. It is the other way about, if on raising the focus the Becke Line moves *outwards* and *away* from the fragment edge, making the centre darker. In other words, on raising the focus, the Becke Line always moves in the direction of a substance of higher index. The observation can be cross-checked by lowering the focus, when the converse is true.

Procedure: For Isotropic substances, take a small quantity of the substance under test and grind it in a small agate mortar to give a powder of about 150 microns then place powder on a microscope slide and spread the particles to avoid overlying and crowding. Select the immersion liquid medium of R.I. matching (or almost matching) the R.I. to be confirmed in the test substance. This is indicated in the monograph by η for isotropic substances. Add a drop of immersion medium to the slide and carefully place a cover slip (10 or 12 mm diameter is preferable) over the particles so that the medium does not exceed the cover slip edges and remain just within it, mount the slide on the rotating stage of the microscope and select a combination of 4x objectives and 10 x eyepieces for observation. Obtain a clear focus on any one particle and by raising or lowering the focus; observe the presence and movement of the Becke Line for several particles in the same field. In case of isotropic substances, with only one R.I., that is η to be confirmed, almost all the particles are practically invisible, the Becke Line faint or absent. This indicates that the substance under test have the same R.I. as the medium, which is known. Repeat observation with more fields in the same mount.

For anisotropic uniaxial substances, follow the same procedure, selecting immersion medium of matching R.I. for η_w in one preparation and for η_e in another preparation. In both, the selected particles remain visible in one position along side a cross wire but the same particles disappear when the stage is rotated through 90° . The sample confirms to the standards in the monograph for the two R.I. s, if the conditions are fulfilled. For anisotropic biaxial substances, the same procedure is followed, using matching immersion media for R.I. η_α and η_γ . In some cases η_β may also have to be confirmed.

2.5. Method of Determination of other constants

Other given constants for anisotropic substances like optic character, optic sign, optic angle and sign of elongation may be determined using polarizing microscope equipped with facility for conoscopic illumination such as Bertrand Lens, Cross-wired eyepiece and accessory plates such as mica plate or quartz red order plate or gypsum plate and quartz wedge etc.

Procedure: Several texts are available (see references) that explain the principles involved and the procedures but some training using reference substances (see Note) is necessary for carrying out the exercises that would obtain compliance with monographic requirements for the crystal characteristics given above. The following paragraphs give a brief outline of the procedures for *uniaxial* and *biaxial* substances with crystal fragments obtained from the sample under test.

A. Uniaxial substances:

A suitable fragment is selected from a preparation mounted in any selected medium and focused under high power. The microscope is adjusted to give conoscopic illumination. A centered *interference figure* is obtained after examining several fragments and on an appropriate figure; the following constants can be determined.

a) Optic character, whether *uniaxial* or *biaxial*:

If the *Interference figure* obtained as above is black cross, with its centre at approximately the centre of the cross wire and remains as such when the stage is rotated through a complete rotation, the substance is *uniaxial*.

b) Optic sign, whether *positive* or *negative*:

Select a crystal showing a black cross as *interference figure*. Introduce the quartz red order plate with etched line parallel to the short axis of the plate into the slot provided in the microscope tube for this purpose. Observe the colour appearing close to the centre of the cross in the North-West and South-East quadrants of the figure. If this is yellow, the substance is positive, and if it is blue, it is negative, colour depending on the line etched on the plate, corresponding to 'slow' vibration direction. Ascertain compliance with monograph.

c) Sign of Elongation:

Examine fragments between crossed nicols; interference figure is not necessary for this. Select crystal that is long and narrow, like a needle. Orient the fragment with the rotating stage, so that its long axis is parallel to the line etched on the quartz plate or the gypsum plate, which is put in the slot for this purpose. If the crystal appears 'blue' the sign of elongation is positive and if 'yellow', it is negative.

B. Biaxial Substances:

The procedure is the same, except that the *interference figure* appears to be a cross but *separates and sweeps out in the form of curves called 'isogyres'*, when the stage is rotated to 90° and meets again in the form of a cross on rotating to 180° from the original position. When such an interference figure is seen on many fragments suitably oriented, the optic character is *biaxial*.

Carry out the same operations as given for *uniaxial* substances for determining the optic sign and the sign of elongation, and interpret the observation in the same manner.

For **Optic Angle**, which is specific for only *biaxial* substances, an approximate estimation of the angle is made out from the curvature of the isogyres, as they sweep out in separation from the cross, by comparing it with a known mineral, say

mica, which has a small optical angle. The optical angle is estimated as '*small*' when the isogyres just part from the cross but remain well within view in the field, '*medium*' when the isogyres move away from the cross point but can still be seen within or at the edge of the field and '*Large*' when they sweep out of the field altogether and disappear, but are brought within the field only after 90° rotation of the stage.

Note: The following minerals may be used as reference substances for learning to compute the monographic requirements in respect of the above characteristics.

Isotropic: *Garnet, sodium chloride and Alum.*

Anisotropic, Uniaxial: *Calcite, quartz, sapphire and ruby.*

Anisotropic, Biaxial: *Iolite, mica, orthoclase and gypsum.*

APPENDIX - 3

Chemical Properties

Description of Different Methods of Chemical
Analyses Adopted by Geological Survey of India
(GSI), Jaipur, Indian Bureau of Mines (IBM), Ajmer
and Indian Bureau of Mines (IBM), Nagpur

&

Qualitative Chemical tests of minerals by Blow Pipe
method

3. CHEMICAL PROPERTIES OF MINERALS AND METALS **(Description of various methods of chemical analyses)**

3.1. Chemical Analysis of Rock/Ore Samples (Gravimetric -- wet analysis method)

3.1.1. Preparation of powdered sample

Prepare finely pulverized homogenous (-) 200 # (mesh) size powdered sample by taking proper care.

The conversion of an ore / rock sample into desired soluble or insoluble species is most important. The method constitutes the fusion of sample rock with solid fluxes to convert complex mineral compound into simple chemical compound. Silicate rock samples are generally analyzed for LOI (Loss of Ignition), SiO₂, Fe₂O₃, Al₂O₃, CaO, MgO, S (T), TiO₂, Na₂O and K₂O.

Dry the sample at 110⁰ in oven for 1 hour before analysis. Cone and quarter the dried sample and preserve half quantity for future reference.

3.1.2. Determination of Loss on Ignition (LOI)

Weigh 1.0 g finely powdered sample in platinum/silica crucible then heat to constant weight in electric muffle furnace at 950-1000⁰ for an hour and allow to cool and weigh.

$$\text{LOI \%} = \frac{W_3 - W_2}{W_2 - W_1} \times 100$$

W₁ = weight of empty crucible

W₂ = weight of crucible + sample

W₃ = weight of crucible + sample after ignition

3.1.3. Determination of Silica (SiO₂)

Procedure:

Weigh 0.5 g (in case of high silica) or 1.0 g (low silica) finely powdered and dried sample in a platinum/silica crucible (W₁). Add 4-5 g anhydrous sodium carbonate into the crucible, mix thoroughly and cover the crucible with lid, if necessary place the crucible in muffle furnace, allow the temperature to rise gradually to reach 900-950⁰ and keep on this temp for about ½ hour to complete the fusion. Take out the crucible and allow cooling at room temperature. Extract the cooled mass in 25-30 ml dilute *hydrochloric acid* in 250 ml beaker followed by heating on hot plate/burner to dissolve the contents. Wash the crucible with *purified water* and keep the beaker on *purified water* bath. Allow to dry the mass to make powder. Take out the beaker and allow cooling at room temp and adding 25-30 ml dilute *hydrochloric acid*, diluting upto 100 ml with *purified water*. Boil the content and

allow to cool then filter through whatman 40 No. filter paper. Wash the residue with hot *purified water* 6-8 times then place the residue along with filter paper in platinum crucible. Ignite at 900- 950⁰ for 2-3 min. Allow to cool and weigh (W₂ g).

$$\% \text{SiO}_2 = \frac{\text{Initial Wt (W}_1) - \text{Final Wt (W}_2)}{\text{Weight of sample (W}_1)} \times 100$$

Note:

Fuse the residue after hydrofluorization with 2-3 g of *potassium pyrosulphate* on burner and allow to cool and extract the mass with dilute *hydrochloric acid* in original filtrate of the sample. Boil to dissolve the residue, if any. Cool the content at room temperature and make up the volume of filtrate to desired volume in 250 ml volumetric flask. Use the stock solution for the determination of other additional radicals as required in the sample.

3.1.4. Determination of Iron (Fe)

Solutions:

- *Stannous chloride* solutions- Dissolve 5.00 mg SnCl₂ (A.R.) in 25 ml *hydrochloric acid* and dilute to 100 ml (5% solution).
- *Mercuric chloride* – Saturated solution in *purified water*.
- *Sulphuric acid* + orthophosphoric acid mixture – take 60 ml *purified water*, add 15 ml *sulphuric acid* and 15 ml *phosphoric acid* cool and dilute to 1000 ml.
- *Diphenyleamine barium sulphonate* – Dissolve 0.25 g in 100 ml *purified water*.
- 0.1N standard *potassium dichromate solution*. Dissolve 4.9035 g A.R. grade in *purified water* and dilute to 1000 ml.

Procedure:

Take a suitable aliquot from the stock solution in 250ml-conical flask in duplicate and dilute to about 100 ml with *purified water* and add 1-2 drops of *methyl red* indicator followed by 1-2 g of *ammonium chloride* and dilute *ammonia solution* was added till brown precipitate appears and solution with precipitate is boiled for 4-5 minutes then the content cooled and filtered through whatman 41 No. filter paper. Wash the residue with hot *purified water* 4-6 times. Dissolve the residue in dilute *hydrochloric acid* in 250 ml beaker and make the volume upto 100 ml approx. then boil the solution on burner to reduce the Fe³⁺ to Fe²⁺ by adding *stannous chloride solution* drop wise till solution becomes colorless. Add 1-2 drops *stannous chloride* in excess and cool the content in *purified water*, then add 10-15 ml 10% solution of *mercuric chloride*, 25ml acid mixture and 2-3 drops of *diphenyl amine barium sulphonate* indicator. Add *purified water*, if required and titrate against standard *potassium dichromate solution*; appearance of violet color shows end point.

Calculation: 1ml 1N $K_2Cr_2O_7$ = 0.05585 g Fe
 = 0.7985 g Fe_2O_3

$$\% Fe = \frac{0.05585 \times \text{normality of } K_2Cr_2O_7 \times \text{aliquot} \times \text{ml } K_2Cr_2O_7 \times 100}{\text{Weight of sample} \times \text{total volume}}$$

3.1.5. Determination of Calcium Oxide (CaO-EDTA) - complexometric method

Solutions:

- 20% *potassium hydroxide* solution – Dissolve 200 g *potassium hydroxide* (A.R.) in *purified water* and make up to 1000 ml.
- *Ammonia buffer solution* 9.5 pH- Dissolve 67.5 g NH_4Cl (A.R.) in 300 ml *purified water*, add 570 ml *ammonia solution* (Analytical Reagent) and dilute to 1000 ml.
- *Ethylene diaminetetraacetic acid* (EDTA) solution 0.05 M- dissolve 18.6120 g of sodium salt of *Ethylene diaminetetraacetic acid* (EDTA) (Analytical Reagent) in *purified water* and make up to 1000 ml.
- *Triethanolamine* 20% solution – 200 ml of *triethanolamine*, add 800 ml *purified water* and make up to 1000 ml.
- Eriochrome Black T indicator 0.1% solution – Dissolve 0.10 g indicators in 100 ml of *methanol*.
- Patterns and Reiders indicators 0.1% solution – Dissolve 0.10 g indicators in 100 ml of *methanol*.

Procedure:

Take one part of filtrate reserved from iron estimation, add 5 ml *triethanolamine* 20% solution and a pinch of *hydroxylamine hydrochloride* then add 25-30 ml *potassium hydroxide* 20% solution. Addition of 4-5 drops of Patterns and Reiders indicator, imparts rose-red color. Titrate the solution against standard *ethylene diaminetetraacetic acid* (EDTA) solution. The color changes from rose- red to Prussian blue indicates end point.

Calculation: 1 ml of 1M EDTA = 0.05608 g CaO

$$\% CaO = \frac{0.5608 \times \text{normality EDTA} \times \text{Aliquot} \times 100 \times \text{ml EDTA}}{\text{Weight of sample} \times \text{total volume}}$$

3.1.6. Determination of Magnesium Oxide (MgO-EDTA) - complexometric method

Take another part of filtrate reserved from Fe estimation, add 5ml *triethanolamine* 20% solution and a pinch of *hydroxylamine hydrochloride* followed by 25-30 ml *ammonia buffer* (9.5 pH) and 4-5 drops of *eriochrome black- T* indicator. Titrate

against standard *ethylene diaminetetraacetic acid* (EDTA) solution appearance of rose- red to blue marks indicates the end point.

Calculation:- 1ml of 1M EDTA = 0.0409 g MgO

$$\% \text{ MgO} = \frac{0.0409 \times \text{normality EDTA} \times \text{aliquot} \times 100 \times \text{ml EDTA}}{\text{Weight of sample} \times \text{total volume}}$$

3.1.7. Determination of Alumina (Al₂O₃-EDTA) - complexo metric method

Solutions:

- 10% *sodium hydroxide solution* – dissolve 100 g *sodium hydroxide* in 100 ml *purified water*.
- EDTA solution 0.05 M- dissolve 18.6120 g of sodium salt of EDTA (A.R.) in *purified water* and make up to 1000 ml.
- Zinc acetate solution 0.05m- dissolve 10.9690 g of *zinc acetate* (A.R.) in 50 ml *purified water* and a few drops of *glacial acetic acid* and dilute to 1000 ml.
- Acetate buffer 5.5 pH- dissolve 21.5 g of *sodium acetate* (Analytical Reagent) in 300 ml *purified water* containing 2 ml *glacial acetic acid* and dilute to 1000 ml.
- *Xylenol orange* indicator – dissolve 0.2 g of *xylenol orange* indicator in 100 ml *purified water* with 2 ml *acetic acid*.

Procedure:

Take suitable aliquot from the stock solution in 250 ml-beaker. Take 50 ml of 10% *sodium hydroxide solution* in another beaker neutralize the aliquot with *sodium hydroxide solution* and transfer the 10% *sodium hydroxide solution* to aliquot with constant stirring add a pinch of sodium carbonate into the solution. Boil the content on burner, cool and filter through whatman 40 No. filter paper with pulp in 600 ml beaker, wash the precipitate with hot *purified water* 6-8 times then acidify the filtrate with dilute *hydrochloric acid* and adjust pH 5.5, normally 25 ml 0.05M *ethylene diaminetetraacetic acid* (EDTA) solution add in excess and 25 ml of acetate buffer solution boil, cool and again adjust the pH to 5-5.5 and add 5-6 drops of *xylenol orange* indicator. Change in color from golden yellow to orange red indicates end point. Take 25 ml 0.05M *ethylene diaminetetraacetic acid* (EDTA) solution and run a blank.

Calculation: 1 ml 1 M Ethylene diaminetetraacetic acid (EDTA) = 1ml 1M Zinc acetate = 0.05098 g Al₂O₃

$$\% \text{ Al}_2\text{O}_3 = \frac{0.05098 \times \text{normality Zn acetate} \times \text{aliquot} \times 100 \times \text{ml Zn acetate}}{\text{Weight of sample} \times \text{total volume}}$$

3.1.8. Determination of Sulphur (total) - gravimetric method

Solutions:

- *Carbon tetrachloride saturated with Bromine*
- *Barium chloride – 10% solution in purified water*

Procedure:

Take 0.5-1.0 g powdered sample in 250 ml beaker. Add 10 ml *carbon tetra chloride* saturated with *bromine* keep in cold condition in fume chamber over night and add 10-15 ml *nitric acid*, digest on water bath then add 10 ml *hydrochloric acid*, digest it to expel NO_2 fumes till syrupy mass is obtained. Cool and extract with *hydrochloric acid*, make volume upto 100 ml, boil and filter through whatman 40 No. filter paper, wash the residue with hot *purified water*. Treat the filtrate with *ammonia* solution for R_2O_3 precipitations, here R stands for Fe and Al. Filter through whatman 41 No. filter paper in 500ml-beaker, acidify the filtrate with *hydrochloric acid* and add 20 ml of 10% *barium chloride* solution Stir the solution and digest on burner. Allow the precipitate to settle for over night. Filter the precipitate through whatman 42 No. filter paper and wash the precipitate with *purified water*. Ignite the precipitate in muffle furnace in pre weighed platinum crucible upto 850° and allow to cool and weigh. Calculate the weight of sulphur by multiplying weight of precipitate with 0.13734.

Calculation:

$$\% \text{ Sulphur (T)} = \frac{\text{Weight of precipitate} \times 0.13734 \times 100}{\text{Weight of sample}}$$

3.1.9. Determination of Lead, Zinc and Copper - complexometric method

Solutions:

- *Acetic acid – ammonium acetate buffer 5.5 - 6.0 pH*, take 200 g *ammonium acetate*, add 30ml *glacial acetic acid* and make up to 1000 ml.
- EDTA solution 0.05 M - Dissolve 18.6120 g of sodium salt of *Ethylene diaminetetraacetic acid* (EDTA) (Analytical Reagent) in *purified water* and make upto 1000 ml.
- *Xylenol orange* indicator - Dissolve 0.2 g indicator in 100ml *purified water*, add 2 drops of *acetic acid*.
- Thio urea (Analytical Reagent)
- *Ascorbic acid* (Analytical Reagent)
- Urea (Analytical Reagent)
- *Sodium fluoride* (Analytical Reagent)

Procedure:

Take 1.0 g powdered sample in a beaker and add 30 ml aquaregia [HNO_3 : HCl , (1:3)] digest it on hot plate. After 15 minutes add 15 ml *sulphuric acid* (1:1), and evaporate the solution to dryness. Dissolve the residue in 10ml *sulphuric acid* (1:1) and make volume to 100 ml with *purified water*. Boil and filter through whatman 40 No. filter paper. Wash the residue with hot *purified water* and make up the filtrate to 250 ml in volumetric flask and reserve for determination of zinc and copper.

3.1.9.i. Determination of Lead**Procedure:**

Take the residue along with filter paper in a beaker and add 50 ml *acetic acid-ammonium acetate* buffer. Boil and filter through whatman 40 No. filter paper, wash the residue with hot *purified water*. To the filtrate, add a pinch of *thiourea* and *ascorbic acid* and 3 drops of *xylene orange* indicator. Titrate the solution against standard 0.05 M *ethylene diaminetetraacetic acid* (EDTA) solution. Purple red color solution changes to lemon yellow color at the end point. Calculate lead content from the *ethylene diaminetetraacetic acid* (EDTA) used up in titration. Calculate lead value against 1 ml of *ethylene diaminetetraacetic acid* (EDTA) solution titrating against standard 1000 ppm lead solution.

Calculation:

$$1\text{ml } 0.05 \text{ N EDTA} = 10.3605 \text{ mg of Pb}$$

$$\% \text{ Lead} = \frac{10.3605 \times \text{Normality of EDTA} \times \text{ml of EDTA} \times \text{Aliquot} \times 100}{\text{Weight of sample (mg)} \times \text{Total volume}}$$

3.1.9.ii. Determination of Zinc**Procedure:**

Take suitable aliquot in a beaker from stock solution and add *ammonia solution* to neutralize the acidity. Add 2 g *urea* and boil vigorously followed by filtration through whatman 40 No. filter paper. Wash the residue with hot water and acidify the filtrate with *acetic acid* and add 0.5 g *ascorbic acid* and *thiourea* each. Add 25 ml *acetic acid- ammonium acetate* buffer and 4-6 drops of *xylene orange* indicator. Titrate against standard 0.05 N *ethylene diaminetetraacetic acid* (EDTA) solution. The color of solution changes from purple red to lemon yellow at the end point. Calculate the zinc content from *ethylene diaminetetraacetic acid* (EDTA) used up in the titration. Calculate zinc value against 1 ml of *ethylene diaminetetraacetic acid* (EDTA) solution titrating against standard 1000 ppm Zinc solution.

Calculation:

$$0.1 \text{ ml } 0.05 \text{ N EDTA} = 3.269 \text{ mg of Zn}$$

$$\% \text{ Zinc} = \frac{3.269 \times \text{Normality of EDTA} \times \text{ml of EDTA} \times \text{Aliquot} \times 100}{\text{Weight of sample (mg)} \times \text{Total volume}}$$

3.1.9.iii. Determination of Copper

Solutions:

- Standard 0.1 N sodium thiosulphate solution.
- Potassium Iodide (A.R.)
- Starch 1% solution –dissolve 1 g in *purified water*, boil and make up to 100ml.

Procedure:

Take suitable aliquot from the stock solution in a beaker and add approx. 1.0 g *sodium fluoride*. Add *ammonia solution* till precipitation occurs and add *acetic acid* to dissolve the precipitate, boil and cool in water bath. Add approximately 1.0g *potassium iodide* and titrate the liberated iodine against 0.1N *sodium thiosulphate* solutions by adding starch solution as indicator in iodine flask. The color changes from blackish brown to white indicates end point. Calculate copper value against 1 ml of *sodium thiosulphate* solution titrating against standard 1000-ppm copper solution.

Calculation: 1ml N $\text{Na}_2\text{S}_2\text{O}_3 = 0.06354$ g of Cu

$$\% \text{ Cu} = \frac{0.06354 \times \text{Normality of } \text{Na}_2\text{S}_2\text{O}_3 \times \text{ml of } \text{Na}_2\text{S}_2\text{O}_3 \times \text{Aliquot} \times 100}{\text{Weight of sample} \times \text{Total volume}}$$

3.1.10. Determination of Chloride in *Sodium chloride* (Common Salt)

Reagent:

- *Silver nitrate* 0.10 M- Dissolve 14.3321 g *Silver nitrate* in *purified water* and make upto 1000 ml.
- *Potassium chromate* indicator, 1.0 % - Dissolve 1.000 g *potassium chromate* in 100 ml *purified water*.

Procedure:

Dissolve 1.000 g sample in *purified water* in a 25 ml beaker then transfer clear solution to 250-ml volumetric flask and make up to mark , pipette out 25 ml sample solution in 250-ml conical flask by adding 1.0 ml *potassium chromate* indicator mix it. Titrate with 0.1M *silver nitrate* solution color changes from yellow to brick red (titration volume, V_1) Run a 1.0ml *potassium chromate* indicator and 25 ml *purified water* blank titration with 0.1M *silver nitrate* solution (titration volume, V_2).

Calculation:

Each ml of 0.1M $\text{AgNO}_3 = 0.003545$ g of Chloride (Cl)

$$\% \text{ Cl} = \frac{0.003545 \times \text{Normality of } \text{AgNO}_3 \times \text{ml of } \text{AgNO}_3 \times \text{Aliquot} \times 100}{\text{Weight of sample (g)} \times \text{Total volume}}$$

3.2. Chemical Analyses of Rock/Ore Samples by Instrumental Methods

3.2.1. Determination of Silver by Atomic Absorption Spectrophotometer (A.A.S.)

Solutions:

- Prepare standard 1000 ppm silver solution from Ag metal or *Silver nitrate*.
- Prepare standard solutions of silver of 1 ppm, 3ppm and 5ppm.

Procedure:

Weigh 0.5 g - 1.0 g powdered sample in 250 ml beaker and add 25 - 30 ml, reverse aquaregia [HNO_3 : HCl (3:1)], digest on hot plate, till syrupy mass is obtained. Neutralize the syrupy digested mass with *ammonia solution* make up the volume to 25-50 ml Make dry filtration through whatman 40 No. filter paper and take observations on 328.1 nm by atomic absorption spectrophotometer

Calculation -

$$\text{Ag ppm} = \frac{\text{Reading (conc.)} \times \text{original volume}}{\text{Weight of sample}}$$

3.2.2. Determination of Copper, Lead, Zinc, Nickel, Cobalt and Cadmium by Atomic Absorption Spectrophotometer

Solutions:

i) Copper

- Prepare 1000 ppm *copper standard solution* from Cu metal.
- Prepare 1ppm, 3 ppm and 5 ppm standard Cu solutions.
- Wavelength - 324.7 nm.

ii) Lead

- Prepare 1000 ppm Lead standard solution from Pb.
- Prepare 1 ppm, 5 ppm and 10 ppm standard Pb solution.
- Wavelength – 283.3 nm.

iii) Zinc -

- Prepare 1000 ppm zinc standard solution from Zn metal.
- Prepare 0.5 ppm, 1.0 ppm and 1.5 ppm standard Zn solution.
- Wavelength – 213.9 nm.

iv) Nickel

- Prepare 1000ppm nickel standard solution from Ni metal.
- Prepare 1ppm, 3ppm and 5ppm standard Ni solution.
- Wavelength – λ 232.0 nm.

v) Cobalt -

- Prepare 1000ppm cobalt standard solution from Co metal (λ 240.7 nm).

vi) Cadmium-

- Prepare 1000ppm Cadmium standard solution Cd metal (λ 228.8 nm).

Procedure:

Weigh 0.10g - powdered sample in 250 - ml beaker and add 25-30 ml aquaregia, [HNO₃:HCl (1:3)] digest on hot plate till syrupy mass is obtained .Filter through whatman 40 No. filter paper in 100 ml volumetric flask. Maintain 1% acidity with *nitric acid* and wash with hot water making volume to 100 ml. Take observations on Atomic Absorption Spectrophotometer on appropriate wavelength as follows:-

Calculation:

$$\text{ppm (metal)} = \frac{\text{Reading (conc.)} \times \text{original volume}}{\text{Weight of sample}}$$

3.2.3. Determination of Tin by Atomic Absorption Spectrophotometer**Solutions:**

- Prepare 1000 ppm Tin standard solution from Sn metal.
- Prepare 22 ppm, 5 ppm and 10 ppm standard Sn solutions.
- Prepare 7.5% *potassium chloride solution in purified water* as buffer.

Procedure:

Weigh 0.5g - 1.0 g powdered sample in 250ml-beaker and add 25-30 ml aquaregia, [HNO₃: HCl (3:1)], digest on hot plate, till syrupy mass is obtained. Extract in *hydrochloric acid* maintain 20% *hydrochloric acid* acidity followed by filtration through whatman 40 No. filter paper, wash with hot water add 2 ml 7.5% *potassium chloride* solution and make up to 100 ml in volumetric flask. Take observations by Atomic Absorption Spectrophotometer on 286.3 nm wavelength.

Calculation:

$$\text{Tin (Sn) ppm} = \frac{\text{Reading (conc.)} \times \text{original volume}}{\text{Weight of sample}}$$

3.2.4. Determination of Antimony by Atomic Absorption Spectrophotometer**Solution:**

- Prepare 10% *tartaric acid solution in purified water*.
- Prepare 7.5% *potassium chloride solution in purified water*.
- Prepare 1000 nm standard Sb solution from Sb metal.
- Prepare 2 ppm, 5 ppm and 10 ppm standard Sb solutions.

Procedure:

Weigh 1.0 g powdered sample in 250ml-beaker and add 25-30 ml aquaregia [HNO₃: HCl (1:3)] digest for one hour on hot plate till syrupy mass is obtained. Filter through whatman 40 No. paper in 100ml-volumetric flask. Wash with hot water and add 10 ml of 10% *tartaric acid*, add 2 ml of 7.5% *potassium chloride* solution. Add *hydrochloric acid* drop wise to get clear solution and make up to 100ml volume. Take observation by Atomic Absorption Spectrophotometer on 217.6 nm wavelengths.

Calculation:

$$\text{Antimony(Sb) ppm} = \frac{\text{Reading (conc.)} \times \text{original volume}}{\text{Weight of sample}}$$

3.2.5. Determination of Bismuth by Atomic Absorption Spectrophotometer**Solutions:**

- Prepare 7.5% *potassium chloride* solution in water.
- Prepare 1000 ppm *standard bismuth solution* from Bi metal.
- Prepare 10 ppm, 20 ppm and 40 ppm standard Bi solutions.
- Prepare 2 ppm, 5 ppm and 10 ppm standard Sb solutions.

Procedure:

Weigh 1.0 g powdered sample in 250ml-beaker and add 25-30 ml aquaregia [$\text{HNO}_3:\text{HCl}$ (1:3)] digest for one hour on hot plate till syrupy mass is obtained. Extract with 10 ml *hydrochloric acid*. Maintain 20% acidity and Filter through whatman No. 40 paper in 100 ml volumetric flask. Wash with hot water and then add 2 ml of 7.5% *potassium chloride* solution make up the volume to 100 ml. Take observation by Atomic Absorption Spectrophotometer on 223.1 nm wavelength.

Calculation:

$$\text{Bismuth(Bi) ppm} = \frac{\text{Reading (conc.)} \times \text{original volume}}{\text{Weight of sample}}$$

3.2.6. Determination of Gold by Atomic Absorption Spectrophotometer**Solutions:**

- Equilibrated MIBK (*methyl isobutyl ketone*) solution - 20% *hydrochloric acid* solution mixes with MIBK in 1:1 ratio. Transfer in separating funnel and shake well to remove heavy metals present as impurities. Separate organic layer of MIBK.
- 5% *hydrochloric acid* solution for washings
- Standard 1000 ppm gold solution from Au metal
- Prepare 1 ppm, 2 ppm and 3 ppm standard Au solution in MIBK medium.
- Conc. *hydrochloric acid* saturated with *bromine*

Procedure:

Weigh 10-20 g of 100 mesh powdered sample in 500 ml conical flask and add 20 ml *hydrochloric acid* saturated with *bromine*. Keep in (cold condition) for two hours and add 50 ml aquaregia [$\text{HNO}_3:\text{HCl}$ (1:3)] digest on hot plate slowly till syrupy mass is obtained. Extract with 10 ml *hydrochloric acid* and heat it. Filter extracted mass through whatman No. 40 filter paper wash with hot water. Transfer the filtrate into a separating funnel and add 25 ml MIBK solution in 3 fractions. Add 5 ml aquaregia into separating funnel and shake the separating funnel 2-3 minutes. Drain off aqueous layer from the separating funnel and wash the organic

layer by 5 ml of 5% *hydrochloric acid* three times drain off aqueous layer. Transfer the organic layer in dry 25 ml volumetric flask. Take observations by Atomic Absorption Spectrophotometer on 242.8 nm wavelength in MIBK medium.

Calculation:

$$\text{Gold(Au) ppm} = \frac{\text{Reading (conc.)} \times \text{original volume}}{\text{Weight of sample}}$$

3.2.7. Determination of Chromium by Atomic Absorption Spectrophotometer

Solutions:

- Prepare 1000 ppm standard chromium solution from Cr Metal or from $\text{K}_2\text{Cr}_2\text{O}_7$.
- Prepare standards 10 ppm, 20 ppm and 40 ppm.
- Prepare 2 ppm, 5 ppm and 10 ppm standard Sb solutions.

Procedure:

Weigh 0.10-0.20 g powdered sample in 250ml-beaker and add 10 ml of 30% solution of *hydrogen peroxide*, add 25-30 ml *perchloric acid* digest for one hour on hot plate till syrupy mass is obtained. Again add 4-5 ml *hydrogen peroxide* and 10 ml *perchloric acid* digest on hot plate till complete digestion. Filter through Whatman No. 40 filter paper wash with hot water and make up in 100ml-volumetric flask. Take observations by Atomic Absorption Spectrophotometer on 357.9 nm

Calculation:

$$\text{Chromium (Cr) ppm} = \frac{\text{Reading (conc.)} \times \text{original volume}}{\text{Weight of sample}}$$

3.2.8. Determination of Arsenic - gutzeit method

Solutions:

- *Potassium iodide* 4% solution - dissolve 4 g *potassium idodide* in *purified water* and make upto 100 ml volume.
- *Stannous chloride* 0.75% solution - dissolve *stannous chloride* in *hydrochloric acid*, boil it and maintain 100 ml volume.
- *Mercuric chloride* 25% solution - dissolve in *ethyl alcohol* in warm condition. Prepare whatman filter paper circles of apparatus size. Soak the circles in *mercuric chloride* solution and dry it.
- *Lead acetate* 15% solution - dissolve *lead acetate* in water with a few ml of *acetic acid* and maintain volume to 100ml. Soak Whatman filter paper pieces. Dry it to keep in glass tube of the apparatus.
- Standard Arsenic solution - Prepare standard Arsenic solutions of 2.5, 5.0 and 10 ppm.

Procedure:

Weight 1.0 g - powdered sample in 250ml-beaker and add 10 ml *bromine* in *hydrochloric acid*, keep it for over night then add 5 ml *nitric acid*, digest on water bath at controlled temperature till syrupy mass is obtained. Add 5 ml conc. *hydrochloric acid* and digest it. Extract the mass in *hydrochloric acid*. Filter through Whatman No. 40 filter paper wash it with hot water and make up to 100 ml. Take 50 ml aliquot in Gutzeit apparatus. Add 6 ml of *potassium iodide* solution then add 10 ml of *stannous chloride* solution to reduce Arsenic, add 2-3 g zinc metal in the container. Add conc. *hydrochloric acid* drop wise from the stopper cork keep *mercuric chloride* soaked filter paper circles in between the stopper and lower glass tube. Keep *lead acetate* soaked filter paper in lower tube join and tight both the portion of apparatus till completion of reaction for 15-20 minutes. AsH_3 gas liberated gives yellow spot on *mercuric chloride* soaked filter paper. Prepare yellow spots of 1,2,4,5 ppm standard Arsenic and compare with unknown samples.

3.2.9. Determination of Mercury (Hg) by cold vapour Atomic Absorption Spectrophotometer (Mercury Analyzer)**Reagents and Standards:**

- Stannous chloride solution (20 % w/v): Dissolve 20 g of *stannous chloride*. 2 water in 25 ml *hydrochloric acid* by boiling; cool and dilute to 100 ml. Add 1-2 g of tin metal.
- Potassium dichromate solution (1% w/v): Dissolve 1 g *potassium dichromate* in 100 ml water.
- Potassium permanganate solution (5% w/v) : Dissolve 5 g *potassium permanganate* in 100 ml *sulphuric acid* (1%v/v)
- Sulphuric acid (1%) – dilute 1 ml of conc. *sulphuric acid* to 100 ml by adding *purified water*.
- Nitric acid (10 % v/v) - dilute 50 ml of *nitric acid* to 500 ml by adding *purified water*.
- Sodium hydroxide (20% w/v)- dissolve 20 g of *sodium hydroxide* pellets in *purified water* and make volume to 100 ml.
- Sulphuric acid (1:1 H_2SO_4) - add 100 ml of *sulphuric acid* to cold *purified water* and make volume to 200 ml.
- Standard Mercury solution:
 - A. Dissolve 0.1354 g of *mercuric chloride* (HgCl_2) in 25 ml of 5% *nitric acid*. Add 1 ml of *potassium dichromate solution* and make upto 100 ml with 5% *nitric acid*.

1 ml of this solution = 1.0 mg Hg/ml = 1000 μg Hg/1 ml = 1000 ppm Hg

- B. Standard 0.10 μg Hg/ml (=100ng Hg / ml):

Prepare 100ng Hg/ml standard solution by successive serial dilution of the 1000 μg / ml Hg solution (10000 times) maintaining 5 % *nitric acid* and 0.01% *potassium dichromate concentration*. This solution is generally stable for 30 days. Prepare this solution preferably fresh every day. Measure absorbance of 0.2 ml, 0.4 ml, 0.6 ml 0.8 ml and 1.0 ml of the above, 100 ng Hg / ml, dilution solution which corresponds to 20, 40, 60, 80 and 100 ng respectively. Plot calibration curve nanogram mercury

versus absorbance. Use this calibration curve for computation of mercury content in unknown sample.

Procedure:

Weigh 2-5g dry fine powder of sample (150 mesh) in a 500 ml conical flask and add 15 ml *nitric acid* and 5 ml *sulphuric acid* then leave flask in ice bath for 90 minutes. Heat on *purified water* bath for 30 minutes and add 150 mg *potassium permanganate* and 3 ml mercury free *hydrochloric acid*. Put a funnel and just heat and then boil gently for 5 minutes, cool and transfer into a 50 ml plastic volumetric conical tube and make upto volume. Centrifuge: Use clear solution for determination of mercury content Run a reagent blank through the procedure. Pipette out 10 ml aliquot into the reaction vessel R₂ of mercury analyzer.

Follow procedure for reading mercury content absorbance as described in instruction/ operation manual of the instrument.

Calculation:

$$\text{Mercury content (ng)} = \frac{\text{Mercury content in aliquot (From calibration graph) ng}}{\text{Weight of the sample (g)}} \times \frac{\text{Total volume of aliquot (50 ml)}}{\text{Volume of aliquot for measurement (10 ml)}}$$

3.2.10. Determination of Gold and Silver by XRF (X-Ray Fluorescence Spectrometry)

Analysis as per the method mentioned in Operation Manual given with the XRF Spectrophotometer.

3.2.11. Determination of small amount of Titanium (TiO₂) by Spectrophotometric method

Solutions:

- Standard TiO₂ Solution – 1000 ppm
- Take 1.0 g TiO₂ in 250 ml beaker. Add 20 ml *sulphuric acid* and 5.0 g *ammonium sulphate*. Digest it till clear solution appears. Cool it and make up to 1000 ml. 1 ml = 1 mg of TiO₂.
- *Sulphuric acid* (A.R.)
- *Orthophosphoric acid* (A.R.)
- Hydrogen per oxide 20 volume

Procedure:

Take 25 ml suitable aliquot form the stock solution and add 5-7 ml 1:1 *sulphuric acid*, fume it off completely till syrupy mass remains, cool and extract with *sulphuric acid* 1:10 in 100 ml volumetric flask to it. Add 10 ml *orthophosphoric acid*. Add 2 ml 30% solution of *hydrogen peroxide* solution. Yellow colour develops completely till syrupy mass remains. Cool and extract with 1:10 *sulphuric acid* in 100 ml volumetric flask. Add 10 ml *orthophosphoric acid* and add 2 ml 30% solution of *hydrogen peroxide* solution. Develop yellow coloured

complex and measure the absorbance at 410 nm run a reagent blank and prepare standard calibration curve. Take 0.5, 1.0, 1.5, 2.0, 4.0, 6.0 and 10.0 mg/ml standard TiO_2 solution, prepare complex and plot a calibration curve and compute the results.

Calculation:

$$\% \text{TiO}_2 = \frac{\text{Concentration (mg)} \times \text{dilution} \times 100 \times 10^{-3}}{\text{Weight of sample}}$$

3.2.12. Determination of Manganese (MnO) by Spectrophotometric method

Solutions:

- Standard Mn solutions 1000 ppm (1 ml = 1 mg)
- Dissolve 2.8755 g of *potassium permanganate* (Analytical Reagent) in 50 ml of *purified water* in 250 ml beaker. Discharge the colour by adding drop by drop 1:1 *hydrochloric acid*. Add 5 ml of 1:1 *sulphuric acid* and digest on hot plate till copious white fumes evolve. Cool it and add 10 ml of 1:1 *sulphuric acid*, dilute it with *purified water* and finally make the solution to 1000 ml volumetric flask.
- *Sulphuric acid* (Analytical Reagent)
- *Orthophosphoric acid* (Analytical Reagent)
- *Potassium per iodate* (Analytical Reagent)

Procedure:

Take 25 ml aliquot from the stock solution in 100ml-volumetric flask and to it add 10 ml *sulphuric acid* 1:1 in volumetric flask. Add 5 ml *orthophosphoric acid* in volumetric flask with 0.1-0.2 g of *potassium periodate* in volumetric flask to produce purple colored permanganic acid. Digest it on *purified water* bath for 15 minutes to develop purple colored complex of Manganese. Cool the volumetric flasks and make up the volume to 100 ml and run a procedure reagent blank with it measure absorbance of purple color complex at 545 nm using suitable spectrophotometer to prepare standard calibration curve. Take 0.5, 1.0, 1.5, 2.0, and 2.5 ml standard Mn solution (a), which corresponds to 0.5 mg, 1.0 mg, 1.5 mg, 2.0 mg and 2.5 mg Manganese. Prepare violet colored complex and plot. Measure absorbance of standards at 545 nm and construct calibration graph (b). Calculate Mn concentration using absorbance - concentration calibration curve of standards.

Calculation:

$$\% \text{Mn} = \frac{\text{mg of Manganese (from calibration graph)} \times 100 \times \text{dilution factor}}{1000 \times \text{wt. of sample (g)}}$$

3.2.13. Estimation of Na₂O and K₂O by Flame Photometry

Procedure:

Take 0.1 to 0.2 g powdered sample in a teflon beaker and add 10 ml *hydrofluoric acid* and 1ml *nitric acid*. Digest on hot plate and dry it then add 5 ml *hydrochloric acid*, digest it. Extract with 5 ml *hydrochloric acid* and make it 100 ml with *purified water* in 100 ml volumetric flask. Dissolve *sodium chloride* and *potassium chloride* for standard 1000 ppm solution. Prepare standard calibration curve. Take 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0 mg / ml standard solutions in 100ml volumetric flask and calibrate the curve and compute the results. Take observations on flame photometer using sodium and potassium filters mode.

Calculation:

$$\% \text{Na}_2\text{O} = \frac{\text{ppm (reading)} \times \text{total volume} \times \text{dilution} \times 100 \times 10^{-6}}{\text{Weight of sample}}$$

$$\% \text{K}_2\text{O} = \frac{\text{ppm (reading)} \times \text{total volume} \times \text{dilution} \times 100 \times 10^{-6}}{\text{Weight of sample}}$$

3.2.14. Determination of Boron by ICPA (Inductively Coupled Plasma Analyser)

Procedure:

Weigh 0.2 g sample in a zirconium crucible and mix with 1 g *sodium peroxide* in the crucible. Fuse the mass on low flame till the color of fused mass changes from yellow to black. Fuse this on high flame till the mass is melt and heat to red hot for 5 minutes then cool the crucible and extract the cool mass with *purified water* in Teflon beaker. Heat the solution on the plate residue gets settled down in the beaker, filter the solution by using Whatman filter paper No. 41 through plastic funnels and collect the filtrate and wash in the Teflon beaker. Acidify the solution by using *nitric acid* and add 2 ml extra to maintain the acidity to make up the volume 250 ml in the polythene volumetric flask. Now the solution is ready to determine the elemental boron by ICPA.

3.3. Methods of Other Important Chemical Studies

3.3.1. Determination of Acid- Insoluble

Take about 1 g pre dried sample (150 mesh) in 250ml-beaker. Add 50 ml dilute *hydrochloric acid*. Stir the solution and cover the beaker by watch glass. Heat on the hot plate at 150° and digest for two hours. Then cool, filter, wash by water and ignite at 900°. Weigh the residue and calculate residue % and report as acid insoluble.

3.3.2. Reaction with Hydrochloric acid, Nitric Acid and Sulphuric Acid

Put 1 g fine powdered (150 mesh) sample in a glass test tube. Add 10 ml concentrated acid. Take observations for change of colour, dissolution, evolution

of any gas and increase or decrease in temperature. Then heat the test tube and again record all the observations stated above.

3.3.3. Effect of Heat

The observations of effect of heat are recorded as "effect of heat in open" and "effect of heat in closed". The effect of heat of mineral is observed by heating 1 g powdered sample in open test tube at 900° . Take observations for change in colour and volume, evolution of any gas and *purified water* etc. For effect of heat in closed, use penfield tube and repeat the same process and observations.

3.3.4. Qualitative Test for Carbonate and Sulphate

Carbonate:

Take about 0.5 g powdered sample in a test tube and add 10-15 ml of dilute *hydrochloric acid* to it. Observe effervescence of CO_2 , *limepurified water* turns – milky white.

Sulphate:

Take about 0.5 g powdered sample in a test tube and add 10-15 ml dilute *hydrochloric acid* and boil then add 10% *barium chloride* solution drop wise to the solution it shows white preipitate of BaSO_4 .

3.4. Qualitative Chemical Tests of Minerals (by Blow Pipe Method)

3.4.1. Essence and Potentialities of the Method:

Blowpipe tests enable qualitative determination of the chemical composition of a mineral without dissolving it. The principle of the method is to intensify and speed oxidation and reduction of the chemical elements of a mineral by heating it in the blowpipe flame and to observe the resulting reaction, which are characteristic of, and diagnostic for a certain element. Blowpipe tests require the following outfit of devices and accessories:

- A blow- pipe
- A charcoal block
- Glass tubes
- A pair of forceps
- Filter paper
- A small glass or porcelain cup
- A candle or an alcohol lamp
- Platinum wire
- An agate or porcelain mortar
- A silver plate or photographic paper
- Coloured glasses
- Strip of test paper, slides and glass sticks

In addition, it is necessary to have the following chemical agents:

- Borax $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ (powder)
- Phosphate $\text{NH}_4\text{NaHPO}_4 \cdot 4\text{H}_2\text{O}$ (Powder)
- Sodium bicarbonate Na_2CO_3 (Powder)
- Cobalt nitrate $\text{Co}(\text{NO}_3)_2$ (1:20) solution
- *Hydrochloric acid* (1:2 solution)

The **blowpipe** is a metal or glass tube with a mouth piece at one end to blow in the air from the lungs and a small opening (0.3-0.6 mm) at the other end, through

which the blown air escapes. Near the narrow end of the tube there is a wide section to collect the moisture introduced with the air. There is different construction of blowpipe. During work, the blowpipe is held by the wide section, the mouth piece is pressed to the lips and air is forced through the small opening of the tube into the flame of an alcohol lamp or a candle, by breathing in through the nose and breathing out through the mouth.

A **charcoal** block is used to produce reduction condition. The preferable size of a charcoal block is 10 by 5 cm. The surface of the block should be flat and smooth. A small pit or 1.5 mm deep and about 5 mm in diameter is cut in the charcoal block at a distance of 1.5-2 cm from the edge. A **platinum** wire should be 0.3-0.5 mm thick and 50 mm long. The wire is welded into a glass stick to be used for obtaining coloured glasses, metallic beads, and for observation of flame colourations. It is possible, though less convenient, to use glass sticks or porcelain fragments for the same purpose. **Glass tubes** 10 to 15 cm long and about 0.5 cm in diameter are used either open or sealed off at one end in a flame. Open-tube tests are made to observe oxidation, and closed tubes are used to accomplish decomposition reactions with no access of air. A **mortar** is used to powder minerals.

A pair of **forceps** is necessary to hold, carry and fix grains of a mineral. It may be of any construction, though it would be better if it is provided with a clamp. A **Silver plate** should have a size of a coin 18 to 20 mm in diameter. It may be replaced by pieces of bromide photographic paper. The silver plate or bromide paper is used to find out whether or not the mineral contains sulphur. **Filter paper** is helpful to see the colouration of solution containing nickel, cobalt or iron. **Coloured glasses** are used to determine the colouration of flame. Three glasses are necessary: blue, red and green. A small **glass or porcelain cup** is used to observe reaction in solution. **Strips of test paper** are convenient to determine acidity or alkalinity.

3.4.2. Structure of candle flame:

The effective application of blow piping requires knowledge of the structure of a candle flame. A flame consists of three parts, the outer of which is invisible, the middle is glowing and the inner is dark. In the outer invisible part gas burns completely, in the middle burning is incomplete and in the inner, most of gas remains unburned. The outer part in an oxidizing flame and the middle part, containing carbon monoxide, hydrogen and hot particles of carbon, is a reduction flame. Introduction of air into the flame with the help of the blowpipe enhances the effect of the oxidizing and reducing flames owing to a high temperature speeding the reactions. Varying the position of the blowpipe and the amount of the blown air, one can intensify either the oxidizing or the reducing flame. To obtain a strong oxidizing flame, one should hold the narrow end of the blowpipe at a right angle to the candlewick so that a stream of air extends the flame into a long tongue. The mineral inserted into the outer, almost non-luminous cone is strongly heated and rapidly oxidizes. Reduction partially occurs in the inner part of the oxidizing flame. But it is not recommended to use it since by changing the angle, blowpipe one can achieve more favourable condition for reduction. For

this purpose, the blowpipe should be inclined so that its tip is at a small distance from the edge of the flame. In this case the blown air produces a broad glowing tongue in the narrow part of which the conditions are most favorable for reduction.

3.4.3. Flame Colourations:

Compounds of alkali and alkali-earth metals and a number of other minerals may volatilize when heated intensely and thus impart characteristic colours to the flame. A flame test may be made by heating a small fragment or powder of the mineral introduced into the oxidizing flame of the blowpipe on a platinum wire or on a glass stick. If the mineral fails to give the characteristic flame, *hydrochloric acid* is applied to it before heating. Coloured glasses are used to differentiate obscured flame. Making a flame test, one should be careful not to introduce into the assay sodium salts whose intense yellow flames tend to mask any other colour. A filter of blue glass will completely absorb the yellow sodium flame. Colour glasses are also used for distinguishing potassium, rubidium, lithium, strontium, calcium, barium, boron and copper flames.

3.4.4. Charcoal Tests:

By performing mineral reduction reactions on charcoal, one can obtain metallic beads and slags; oxidation reaction yield characteristic oxide coatings. Mineral powder (or grains) is held in a pit cut in a charcoal block and heated by the blowpipe flame so that the block and the flame form an angle of about 45° . Apart from obtaining metallic beads, slags and oxide coatings, charcoal tests enable one to observe fusibility, cracking appearance of odour, colouration and glowing of the flame. All these factors are very helpful in mineral identification.

Sulphides and the like sulphurous, antimonial and arsenious minerals of lead copper and other heavy metals are placed on the charcoal and reduced by the blowpipe flame to free metals. Infusible sulphates, silicates and other metal compounds should be mixed with soda in the proportion of 1 to 3 to form a carbonate flux facilitating melting of the oxides which, in turn, are easily reduced to metals.

The reduced metal either forms a metallic bead or remains in grains and scales. The reactions of mineral reduction on the charcoal are particularly characteristic of lead, silver, tin, antimony, bismuth, gold, copper, iron, nickel and cobalt. The charcoal tests in the oxidizing flame are effective for bismuth, antimony, arsenic, tin, zinc, lead and selenium. The useful diagnostic features are oxide coating formed on the charcoal block, their colour, shape, location, volatility and sometimes odour of fumes.

In view of the fact that temperature of coating formation is different for different metals, slow heating enables determination of several metals in one assay. First, coating of arsenic and antimony oxides is formed, then those of lead, bismuth, zinc, and tin. Selenium and sulphur do not yield coatings but volatilize, giving

off white fumes with a strong characteristic odour resembling in the case of selenium that of radish.

3.4.5. Closed Tube and Open Tube Tests

3.4.5.i. Closed Tube Test:

When a mineral is heated in the closed glass tube, one can observe cracking, glowing, melting, change of colour, gas emanation, sublimation or other characteristic processes. To observe these processes, the closed end of the penfield tube with the powdered mineral is heated in the oxidizing flame at 1000° of the blowpipe. The tube, held at an angle of 45° to the flame, is slowly heated first in a small and then in a very hot flame until it becomes red. As a result of decomposition, the mineral gives off fumes with some products remaining on the walls of the tube as characteristic sublimates. In this way, one can find out whether or not the minerals under test contain *purified water*, oxygen, sulphur, arsenic and mercury. Absorbed *purified water* is given off to form drops on the walls of the tube, with hygroscopic *purified water* being given off on weak heating and crystallization and constitutional *purified water* on red heating. The *purified water* thus obtained may be tested for acidity with the help of test paper. Oxygen can be recognised by bright burning of a coal grain dropped into the tube above the mineral powder.

3.4.5.ii. Open Tube Test:

The small fragment is placed in the tube about an inch from the lower end, the tube being slightly inclined (say 20°) but not enough to cause the mineral to slip out and heat applied beneath. The current of air passing upward through the tube during the heating process (at 1000°) has an oxidizing effect. The special phenomena to be observed are the formation of a sublimate and the odour of the escaping gases. The acid or alkaline character of the vapours is tested for in the same way as with the closed tubes. The most common gas evolved in this way is sulphur dioxide SO_2 , when sulphides are being oxidized. This gas can be recognised by its irritating, pungent odour and its acid reaction upon moistened blue litmus paper.

3.4.6. Colour Reactions with Fluxes:

When borax and salt of phosphorus are fused in the blowpipe flame, they are transformed to metaborax and metaphosphorus salts which react with the tested mineral to produce coloured borates and phosphates known as coloured glasses or beads. To prepare a coloured bead, platinum wire should be moistened with *purified water* or heated, and then dipped into powdered borax or salt of phosphorus and heated in the oxidizing flame of the blowpipe. The powder melts to a colourless liquid and on cooling forms a small glass bead. To prepare a bead 2-3 mm in diameter, the procedure should be repeated 2-3 times. The bead thus obtained should be moistened with *purified water* or heated again to make the grain of the mineral to be tested stick to it. The bead with the grain should then

be reheated in the oxidizing flame until the whole of the bead becomes coloured. In this test the bead colour refer to the chemical element having the highest balance.

To perform a reduction bead test, the bead should first be heated in the oxidizing flame and then in the reducing flame. To avoid extra loss of platinum, prior to bead preparation, the mineral should be heated in the oxidizing flame on the charcoal. By this heating, volatile components, such as sulphur, arsenic and antimony, which fuse with platinum, will be eliminated from the mineral. Besides, transformation of other metallic compounds to oxides enhances characteristic colours of the beads.

3.4.7. Recommended Procedure of Blowpipe Tests

If, starting the blowpipe tests, one has no idea of the composition of the mineral to be tested he is advised to perform the operations in the following succession:

- i) Observation of flame colouration
- ii) Charcoal tests
- iii) Closed-tube tests
- iv) Observation of bead colouration

To check whether or not the mineral contains a certain element, the testing should start with the reactions, which are most sensitive to the suspected element and ignore the recommended general succession.

1. Flame colouration tests are used to determine the presence of lithium, potassium, sodium, calcium, barium, strontium, copper (oxides) and boron.
2. Charcoal tests help to obtain the following results:
 - 2.1 if the mineral melts and yields only a coating, it is likely to contain arsenic or zinc;
 - 2.2 if the mineral melts and gives a bead and a coating, it may contain antimony, bismuth, tin or lead;
 - 2.3 if the mineral melts and produces only a bead, it may contain silver, gold or copper;
 - 2.4 if the mineral does not melt and forms a magnetic mass, it obviously contains iron, nickel and cobalt;
 - 2.5 if the mineral mixed with soda and heated in the reducing flame produces a "sulphur silver" reaction on a silver plate or photographic paper (when moistened with purified water), it apparently contains sulphur;
 - 2.6 if a colourless or a poorly coloured bead moistened with cobalt nitrate solution and reheated in the oxidizing flame turns blue, aluminum is present; green, zinc; and pink, magnesium.
3. Observation of sublimates in closed-tube tests enables determination of Sulphur, Arsenic and Mercury.
4. Colour reactions with fluxes (borax and salt of phosphorus) help to distinguish manganese, iron, chromium, copper, nickel, cobalt and titanium.

APPENDIX - 4
Chemicals and Reagents

4. CHEMICALS AND REAGENTS

Acetic Acid – Contains approximately 33 per cent w/v of $C_2H_4O_2$. Dilute 315 ml of glacial acetic acid to 1000 ml with *water*.

Acetic Acid, Glacial – $CH_3COOH = 60.05$.

Contains not less than 99.0 per cent w/w of $C_2H_4O_2$. About 17.5 N in strength.

Description – At temperature above its freezing point a clear colourless liquid, odour, pungent and characteristic; crystallises when cooled to about 10^0 and does not completely re-melt until warmed to about 15^0 .

Solubility – Miscible with *water*, with *glycerine* and most fixed and volatile oils.

Boiling range – Between 117^0 and 119^0 .

Congearing temperature – Not lower than 14.8^0 .

Wt. per ml – At 25^0 about 1.047 g.

Heavy metals –Evaporate 5 ml to dryness in a porcelain dish on water-bath, warm the residue with 2 ml of 0.1 N *hydrochloric acid* and water to make 25 ml; the limit of heavy metals is 10 parts per million, Appendix 2.3.3.

Chloride –5 ml complies with the limit test for chlorides.

Sulphate –5 ml complies with the limit test for sulphates,

Certain aldehydic substances – To 5 ml add 10 ml of *mercuric chloride solution* and make alkaline with *sodium hydroxide solution*, allow to stand for five minutes and acidify with dilute *sulphuric acid*; the solution does not show more than a faint turbidity.

Formic acid and oxidisable impurities – Dilute 5 ml with 10 ml of water, to 5 ml of this solution add 2.0 ml of 0.1 N potassium dichromate and 6 ml of sulphuric acid, and allow to stand for one minute, add 25 ml of water, cool to 15^0 , and add 1 ml of freshly prepared potassium iodide solution and titrate the liberated iodine with 0.1 N sodium thiosulphate, using starch solution as indicator. Not less than 1 ml of 0.1 N *sodium thiosulphate* is required.

Odorous impurities –Neutralise 1.5 ml with *sodium hydroxide solution*; the solution has no odour other than a faint acetous odour.

Readily oxidisable impurities – To 5 ml of the solution prepared for the test for Formic Acid and Oxidisable Impurities, add 20 ml of water and 0.5 ml of 0.1 *N* potassium permanganate; the pink colour does not entirely disappear within half a minute.

Non-volatile matter – Leaves not more than 0.01 per cent w/w of residue when evaporated to dryness and dried to constant weight at 105°.

Assay – Weigh accurately about 1 g into a stoppered flask containing 50 ml of water and titrate with *N* sodium hydroxide, using phenolphthalein solution as indicator. Each ml of sodium hydroxide is equivalent to 0.06005 g of C₂H₄O₂.

Acetic Acid, Lead-Free – Acetic acid which complies with following additional test, boil 25 ml until the volume is reduced to about 15 ml, cool make alkaline with lead-free ammonia solution, add 1 ml of lead free potassium cyanide solution, dilute to 50 ml with water, add 2 drops of sodium sulphide solution; no darkening is produced.

Acetate buffer 5.5 pH– Dissolve 21.5 g of sodium acetate (Analytical Reagent) in 300 ml water containing 2 ml glacial acetic acid and dilute to 1000 ml

Alcohol –

Description – Clear, colourless, mobile, volatile liquid, odour, characteristic and spirituous; taste, burning, readily volatilised even at low temperature, and boils at about 78°, flammable. Alcohol containing not less than 94.85 per cent v/v and not more than 95.2 per cent v/v of C₂H₅OH at 15.56°.

Solubility – Miscible in all proportions with water, with chloroform and with solvent ether.

Acidity or alkalinity – To 20 ml add five drops of phenolphthalein solution; the solution remains colourless and requires not more than 2.0 ml of 0.1 *N* sodium hydroxide to produce a pink colour.

Specific gravity – Between 0.8084 and 0.8104 at 25°.

Clarity of solution – Dilute 5 ml to 100 ml with water in glass cylinder; the solution remains clear when examined against a black background. Cool to 10° for thirty minutes; the solution remains clear.

Methanol – To one drop add one of water, one drop of dilute phosphoric acid, and one drop of potassium permanganate solution. Mix, allow to stand for one minute and add sodium bisulphite solution drop wise, until the permanganate colour is discharged. If a brown colour remains, add one drop of dilute phosphoric acid. To the colourless solution add 5 ml of freshly prepared chromotropic acid solution and heat on a water-bath at 60° for ten minutes; no violet colour is produced.

Foreign organic substances – Clean a glass-stoppered cylinder thoroughly with *hydrochloric acid*, rinse with water and finally rinse with the alcohol under examination. Put 20 ml in the cylinder, cool to about 15° and then add from a carefully cleaned pipette 0.1 ml 0.1 *N* *potassium permanganate*. Mix at once by inverting the stoppered cylinder and allow to stand at 15° for five minutes; the pink colour does not entirely disappear.

Isopropyl alcohol and t-butyl alcohol – To 1 ml add 2 ml of water and 10 ml of *mercuric sulphate solution* and heat in a boiling water-bath; no precipitate is formed within three minutes.

Aldehydes and ketones – Heat 100 ml of *hydroxylamine hydrochloride solution* in a loosely stoppered flask on a water-bath for thirty minutes, cool, and if necessary, add sufficient 0.05 *N* *sodium hydroxide* to restore the green colour. To 50 ml of this solution add 25 ml of the alcohol and heat on a water bath for ten minutes in a loosely stoppered flask. Cool, transfer to a *Nessler cylinder*, and titrate with 0.05 *N* *sodium hydroxide* until the colour matches that of the remainder of the *hydroxylamine hydrochloride solution* contained in a similar cylinder, both solutions being viewed down the axis of the cylinder. Not more than 0.9 ml of 0.05 *N* *sodium hydroxide* is required.

Fusel oil constituents – Mix 10 ml with 5 ml of water and 1 ml of *glycerin* and allow the mixture to evaporate spontaneously from clean, odourless absorbent paper; no foreign odour is perceptible at any stage of the evaporation.

Non-volatile matter – Evaporate 40 ml in a tared dish on a water-bath and dry the residue at 105° for one hour; the weight of the residue does not exceed 1 mg.

Storage – Store in tightly-closed containers, away from fire.

Labelling – The label on the container states “Flammable”.

Alcohol, Aldehyde-free. –Alcohol which complies with the following additional test :

Aldehyde – To 25 ml, contained in 300 ml flask, add 75 ml of *dinitrophenyl hydrazine solution*, heat on a water bath under a reflux condenser for twenty four hours, remove the alcohol by distillation, dilute to 200 ml with a 2 per cent v/v solution of sulphuric acid, and set aside for twenty four hours; no crystals are produced.

Alcohol, Sulphate-free. –Shake alcohol with an excess of anion exchange resin for thirty minutes and filter.

Ascorbic Acid – $C_6H_8O_6=176.13$

Description – Colourless crystals or white to very pale yellow crystalline powder; odourless. On exposure to light it gradually darkens.

Solubility – Freely soluble in water, sparingly soluble in *ethanol* (95%); insoluble in *chloroform*, in *ether* and in *benzene*.

Storage – Store in tightly-closed, light-resistant containers and avoid contact with metals. It undergoes rapid decomposition in solutions in contact with air.

Standards – Ascorbic Acid contains not less than 99.0 per cent and not more than 100.5 per cent of $C_6H_8O_6$.

Ammonia – Ammonia solution strong contains not less than 27 percent w/w and not more than 30 percent w/w of NH_3 .

Ammonia buffer (9.5 pH) – Dissolve 33.5 g of ammonium chloride in 150 ml of water and 42 ml of 10M ammonia and dilute with water to 250 ml.

Store in polyethylene containers.

Ammonia, xN. – Solutions of any normality XN may be prepared by diluting 75 x ml of strong ammonia solution to 1000 ml with water.

Ammonia Solution, Iron-free – Dilute ammonia solution which complies with the following additional test :-

Evaporate 5 ml nearly to dryness on a water-bath add 40 ml of water, 2 ml of 20 per cent w/v solution of iron free citric acid and 2 drops of thioglycollic acid, mix, make alkaline with iron-free ammonia solution and dilute to 50 ml with water, no pink colour is produced.

Ammonium Acetate – $CH_3CO_2NH_4$

Description – Colourless crystals or crystalline masses; odour, slightly acetous, very deliquescent.

Solubility – Very soluble in water, and in alcohol

Reaction – Dissolve 1 g in 20 ml of carbon-dioxide free water; the reaction of the solution is not more acid than pH 6:5 using solution of bromothymol blue as indicator.

Chloride – 3.5 g complies with the limit test for chlorides

Sulphate – Dissolve 4 g in 5 ml of water, add 10 mg of sodium bicarbonate, evaporate to dryness and heat at 120 until the ammonium acetate is volatilised. The residue complies with the limit test for sulphates.

Sulphated Ash – Not more than 0.035 percent.

Ammonium chloride - NH_4Cl

Description – A white, crystalline, granular powder; odourless; taste, saline and cooling; somewhat hygroscopic.

Solubility – Soluble in 2.6 parts of water, in 1.4 parts of boiling water and in about 100 parts of alcohol.

Reaction – pH of a 5 percent w/v solution, between 4.5 and 6.0.

Sulphate – 2 g complies with the limit test for sulphates.

Sulphated ash – Not more than 0.1 percent

Ammonium Chloride Solution –A 10.0 per cent w/v solution of *ammonium chloride* in water.

Ammonium molybdate- $\text{NH}_4\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}$ = 1235.86

White crystal or crystalline masses, sometimes with a yellowish or green tint.

Ammonium Thiocyanate – NH_4SCN = 76.12.

Description –Colourless crystals.

Solubility – Very soluble in water, forming a clear solution, readily soluble in alcohol.

Chloride –Dissolve 1 g in 30 ml of solution of hydrogen peroxide, add 1 g of *sodium hydroxide*, warm gently, rotate the flask until a vigorous reaction commences and allow to stand until the reaction is complete; add a further 30 ml of *hydrogen peroxide solution* boil for two minutes, cool, and add 10 ml of *dilute nitric acid* and 1 ml of *silver nitrate solution*; any opalescence produced is not greater than that obtained by treating 0.2 ml of 0.01 *N hydrochloric acid* in the same manner.

Sulphated ash –Moisten 1 g with *sulphuric acid* and ignite gently, again moisten with sulphuric acid and ignite; the residue weighs not more than 2.0 mg.

Ammonium Thiocyanate, 0.1N – NH_4SCN = 76.12; 7.612 in 1000 ml. Dissolve about 8 g of *ammonium thiocyanate* in 1000 ml of water and standardise the solution as follows :

Pipette 30 ml of standardised 0.1 *N silver nitrate* into a glass stoppered flask, dilute with 50 ml of *water* then add 2 ml of *nitric acid* and 2 ml of *ferric ammonium sulphate solution* and titrate with the *ammonium thiocyanate solution* to the first appearance of a red brown colour. Each ml of 0.1N *silver nitrate* is equivalent to 0.007612 g of NH_4SCN .

Ammonium Thiocyanate Solution – A 10.0 per cent w/v solution of *ammonium thiocyanate solution*.

Barium chloride– BaCl_2 = 208.233

Description – Colourless crystals

Solubility – 1g dissolves completely in 5 ml of water

Lead – Dissolve 1 g in 40 ml. of recently boiled and cooled water, add 5 ml of lead free acetic acid, render alkaline with lead free solution of ammonia and add 2 drops of lead free solution of sodium sulphide. Not more than a slight colour is produced.

Nitrate – Dissolve 1 g in 10 ml of water add 1 ml of solution of indigo carmine and 10 ml of nitrogen-free sulphuric acid and heat to boiling. The blue colour does not entirely disappear.

Borax - Sodium Tetraborate, $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ = 381.37.

Contains not less than 99.0 per cent and not more than the equivalent of 103.0 per cent of $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$.

Description –Transparent, colourless crystals, or a white, crystalline powder; odourless, taste, saline and alkaline. Effloresces in dry air, and on ignition, loses all its water of crystallisation.

Solubility –Soluble in water, practically insoluble in alcohol.

Alkalinity –A solution is alkaline to litmus solution.

Heavy metals – Dissolve 1 g in 16 ml of water and 6 ml of *N* hydrochloric acid and add water to make 25 ml; the limit of heavy metals is 20 parts per million,

Iron –0.5 g complies with the *limit test for iron*,

Chlorides –1 g complies with the *limit test for chlorides*,

Sulphates –1 g complies with the *limit test for sulphates*,

Assay –Weigh accurately about 3 g and dissolve in 75 ml of water and titrate with 0.5 *N* hydrochloric acid, using *methyl red solution* as indicator. Each ml of 0.5 *N* hydrochloric acid is equivalent to 0.09534 g of $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$.

Storage – Preserve Borax in well-closed container.

Copper Sulphate – $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ = 249.68

Contains not less than 98.5 per cent and not more than the equivalent of 101.0 per cent of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$.

Description –Blue triclinic prisms or a blue, crystalline powder.

Solubility –Soluble in water, very soluble in boiling water, almost insoluble in alcohol; very slowly soluble in glycerin.

Acidity and clarity of solution – 1 g, dissolved in 20 ml of water, forms a clear blue solution, which becomes green on the addition of 0.1 ml of *methyl orange solution*.

Iron – To 5 g, add 25 ml of water, and 2 ml of nitric acid, boil and cool. Add excess of *strong ammonia solution*, filter, and wash the residue with *dilute ammonia solution* mixed with four times its volumes of water. Dissolve the residue, if any, on the filter with 2 ml of *hydrochloric acid*, diluted with 10 ml of water; to the acid solutions add *dilute ammonia solution* till the precipitation is complete; filter and wash; the residue after ignition weighs not more than 7 mg.

Copper Sulphate, Anhydrous – $\text{CuSO}_4 = 159.6$

Prepared by heating copper sulphate to constant weight at about 230° .

Copper Sulphate Solution – A 10.0 per cent w/v solution of *copper sulphate* in water.

Cresol Red – 4,4', -(3H-2, 1-Benzoxathiol-3 ylidene) di-O-cresol SS-dioxide; $\text{C}_{12}\text{H}_8\text{O}_5\text{S} = 382.4$.

Gives a red colour in very strongly acid solutions, a yellow colour in less strongly acid and neutral solutions, and a red colour in moderately alkaline solutions (pH ranges, 0.2 to 1.8, and 7.2 to 8.8).

Cobalt nitrate Co (NO₃)₂

Cobaltous Nitrate; Cobalt (II) Nitrate : $\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} = 291.03$

Red crystals; deliquescent.

Cresol Red Solution – Warm 50 ml of *cresol red* with 2.65 ml of 0.05 M *sodium hydroxide* and 5 ml of *ethanol* (90 per cent); after solution is effected, add sufficient *ethanol* (20 per cent) to produce 250 ml.

Sensitivity – A mixitue of 0.1 ml of the solution and 100 ml of *carbon dioxide-free water* to which 0.15 ml of 0.02 M *sodium hydroxide* has been added is purplish-red. Not more than 0.15 ml of 0.02 M *hydrochloric acid* is required to change the colour to yellow.

Diphenyl Amine Barium Sulphonate Indicator Dissolve 0.25 g in 100 ml water.

Disodium Ethylenediamine tetraacetate – (*Disodium Acetate*) $\text{C}_{10}\text{H}_{14}\text{N}_2\text{Na}_2\text{O}_8 \cdot 2\text{H}_2\text{O} = 372.2$.

Ethylene diamine tetra acetic acid (EDTA) solution 0.05 M- dissolves 18.6120 g of sodium salt of Ethylene diamine tetraacetic acid (EDTA) (Analytical Reagent) in water and make up to 1000 ml

Eriochrome Black T – Mordant Black 11; Sodium 2(1-hydroxy-2-naphthylazo) 5-nitro-2-naphthol-4-sulphonate; $\text{C}_{20}\text{H}_{12}\text{N}_3\text{NaO}_7\text{S} = 461.38$.

Brownish black powder having a faint, metallic sheen, soluble in alcohol, in *methyl alcohol* and in hot water.

Ethyl Alcohol – $\text{C}_2\text{H}_5\text{OH}$ = 46.07.

Absolute Alcohol; Dehydrated Alcohol.

Description –Clear, colourless, mobile, volatile liquid; odour, characteristic and spirituous; taste, burning; hygroscopic. Readily volatilisable even at low temperature and boils at 78^0 and is flammable.

Solubility –Miscible with water, with solvent ether and with chloroform.

Contains not less than 99.5 per cent w/w or 99.7 per cent v/v of $\text{C}_2\text{H}_5\text{OH}$.

Identification –Acidity or Alkalinity; Clarity of Solution; Methanol; Foreign organic substances; Isopropyl alcohol and butyl alcohol; Aldehydes and ketones; fusel oil constituents; Non-volatile matter; complies with the requirements described under Alcohol.

Specific gravity –Between 0.7871 and 0.7902, at 25^0 .

Storage –Store in tightly closed containers in a cool place away from fire and protected from moisture.

Labelling –The label on the container states “Flammable”.

Formic acid- HCOOH = 46.03

Description:-Colourless liquid, odour, very pungent, highly corrosive; wt per ml. about 1.20 g, contains about 90.0 per cent of HCOOH and is about 23.6 M in strength.

Assay:- Weigh accurately, a conical flask containing 10ml of water, quickly add about 1ml of the reagent being examined and weigh again. Add 50ml of water and titrate with 1M sodium hydroxide using 0.5 ml of phenolphthalein solution as indicator. Each ml of 1M sodium hydroxide is equivalent to 0.04603 g of HCOOH .

Hydrochloric Acid – HCl = 36.46

Concentrated Hydrochloric Acid

Description –Clear, colourless, fuming liquid; odour, pungent.

Arsenic –Not more than 1 part per million, Appendix 2.3.1.

Heavy metals –Not more than 5 parts per million, determined by Method A on a solution prepared in the following manner : Evaporate 3.5 ml to dryness on a water-bath, add 2 ml of dilute acetic acid to the residue, and add water to make 25 ml,.

Bromide and iodide –Dilute 5 ml with 10 ml of *water*, add 1 ml of *chloroform*, and add drop by drop, with constant shaking, *chlorinated lime solution*; the chloroform layer does not become brown or violet.

Sulphite –Dilute 1 ml with 10 ml of *water*, and add 5 drops of *barium chloride solution* and 0.5 ml of 0.001 *N iodine*; the colour of the iodine is not completely discharged.

Sulphate –To 5 ml add 10 mg of sodium bicarbonate and evaporate to dryness on a water bath; the residue, dissolved in *water*; complies with the *limit test for sulphates*. *Free chlorine* –Dilute 5 ml with 10 ml of freshly boiled and cooled *water*, add 1 ml of cadmium *iodide solution*, and shake with 1 ml of *chloroform*; the chloroform layer does not become violet within one minute.

Sulphated ash –Not more than 0.01 per cent.

Assay –Weigh accurately about 4 g into a Stoppard flask containing 40 ml of *water*, and titrate with *N sodium hydroxide*, using *methyl orange solution* as indicator. Each ml of *N sodium hydroxide* is equivalent to 0.03646 g of HCl.

Storage –Store in glass-stoppered containers at a temperature not exceeding 30⁰.

Hydrochloric Acid, x N –Solution of any normality x N may be prepared by diluting 84 x ml of *hydrochloric acid* to 1000 ml with *water*.

Hydrochloric Acid –(1 per cent w/v) Dilute 1 g of *hydrochloric acid* to 100 ml with *water*.

Dilute Hydrochloric Acid –

Description –Colourless liquid.

Arsenic, Heavy metals bromoide and iodide, Sulphate, free chlorine –Complies with the tests described under Hydrochloric Acid, when three times the quantity is taken for each test.

Assay –Weigh accurately about 10 g and carry out the Assay described under Hydrochloric Acid.

Storage –Store in stoppered containers of glass or other inert material, at temperature below 30⁰.

Hydrochloric Acid, N – HCl = 36.460

36.46 g in 1000 ml

Dilute 85 ml of hydrochloric acid with water to 1000 ml and standardise the solution as follows:

Weigh accurately about 1.5 g of anhydrous sodium carbonate, previously heated at about 270° for one hour. Dissolve it in 100 ml of *water* and add two drops of *methyl red solution*. Add the acid slowly from a burette with constant stirring, until the solution becomes faintly pink. Heat again to boiling and titrate further as necessary until the faint pink colour no longer affected by continued boiling. Each 0.5299 g of *anhydrous* sodium carbonate is equivalent to 1 ml of N hydrochloric acid.

Hydrochloric Acid, Iron-Free –Hydrochloric acid, which complies with the following additional test. Evaporate 5 ml on a water-bath nearly to dryness, add 40 ml of water, 2 ml of a 20 per cent w/v solution of citric acid and two drops of thioglycollic acid, mix, make alkaline with *dilute ammonia solution*, and dilute to 50 ml with water; no pink colour is produced.

Hydrofluoric Acid – HF=20.01

Colourless, Corrosive liquid; odour, pungent; wt. per ml, about 1.13 g; contains not less than 40% w/w of HF. Store in polyethylene or gutta percha bottles.

Hydrogen Peroxide Solution – (20 Vol.) H₂O₂ = 34.02

Commerce or *hydrogen peroxide solution* (100 Vol.) diluted with 4 volumes of water.

A colourless liquid containing about 6 per cent w/v of H₂O₂; weight per ml, about 1.02 g.

Hydroxylamine Hydrochloride; Hydroxylammonium Chloride – NH₂OH.HCl = 69.49.

Contains not less than 97.0 per cent w/w of NH₂OH. HCl.

Description –Colourless crystals, or a white, crystalline powder.

Solubility –Very soluble in water; soluble in alcohol.

Free acid –Dissolve 1.0 g in 50 ml of *alcohol*, add 3 drops of *dimethyl yellow solution* and titrate to the full yellow colour with *N sodium hydroxide*; not more than 0.5 ml of *N sodium hydroxide* is required.

Sulphated ash –Not more than 0.2 per cent, Appendix 2.2.6.

Assay –Weigh accurately about 0.1 g and dissolve in 20 ml of water, add 5 g of ferric ammonium sulphate dissolve in 20 ml of water, and 15 ml of *dilute sulphuric acid*, boil for five minutes, dilute with 200 ml of water, and titrate with 0.1 *N potassium permanganate*. Each ml of 0.1 *N potassium permanganate* is equivalent to 0.003475 g of NH₂OH. HCl.

Hydroxylamine Hydrochloride Solution –Dissolve 1 g of *hydroxylamine hydrochloride* in 50 ml of *water* and add 50 ml of *alcohol*, 1 ml of *bromophenol blue solution* and 0.1 *N sodium hydroxide* until the solution becomes green.

Mercury – Hg = 200.59

Shinning, Silvery-white, heavy liquid, easily divisible into globules and extremely mobile; readily volatilises on heating; wt. per ml, about 13.5 g.

Mercuric Chloride – HgCl_2 =271.50.

Contains not less than 99.5 per cent of HgCl_2 ;

Description –Heavy, colourless or white, crystalline masses, or a white crystalline powder.

Solubility –Soluble in *water*; freely soluble in *alcohol*.

Non-volatile matter –When volatilised, leaves not more than 0.1 per cent of residue.

Assay –Weigh accurately about 0.3 g and dissolve in 85 ml of *water* in a stoppered-flask, add 10 ml of *calcium chloride solution*, 10 ml of *potassium iodide solution*, 3 ml of *formaldehyde solution* and 15 ml of *sodium hydroxide solution*, and shake continuously for two minutes. Add 20 ml of acetic acid and 35 ml of 0.1 *N iodine*. Shake continuously for about ten minutes, or until the precipitated mercury is completely redissolved, and titrate the excess of iodine with 0.1 *N sodium thiosulphate*. Each ml of 0.1 *N iodine* is equivalent to 0.01357 g of HgCl_2 .

Mercuric Chloride, 0.2 M – Dissolve 54.30 g of *mercuric chloride* in sufficient *water* to produce 1000 ml.

Mercuric Chloride Solution –A 5.0 per cent w/v solution of *mercuric chloride* in *water*.

Methyl Alcohol : Methanol : CH_3OH = 32.04.

Description –Clear, Colourless liquid with a characteristic odour.

Solubility –Miscible with *water*, forming a clear colourless liquid.

Specific Gravity – At 25° , not more than 0.791.

Distillation range – Not less than 95 per cent distils between 64.5° and 65.5° .

Refractive Index –At 20° , 1.328 to 1.329.

Acetone –Place 1 ml in a *Nessler cylinder*, add 19 ml of *water*, 2 ml of a 1 per cent w/v solution of 2-nitrobenzaldehyde in *alcohol (50 per cent)*, 1 ml of 30 per cent w/v solution of *sodium hydroxide* and allow to stand in the dark for fifteen minutes. The colour developed does not exceed that produced by mixing 1 ml of standard acetone solution, 19 ml of *water*, 2 ml of the solution of 2-nitrobenzaldehyde and 1 ml of the solution of *sodium hydroxide* and allowing to stand in the dark for fifteen minutes.

Acidity –To 5 ml add 5 ml of *carbon dioxide-free water*, and titrate with 0.1 *N sodium hydroxide*, using *bromothymol blue solution* as indicator; not more than 0.1 ml is required.

Non-volatile matter – When evaporated on a water-bath and dried to constant weight at 105°, leaves not more than 0.005 per cent w/v of residue.

Methyl Alcohol, Dehydrated –Methyl alcohol, which complies with the following additional requirement.

Water –Not more than 0.1 per cent w/w.

Methyl Orange – Sodium-*p*-di methylamineazobenzene sulphate, $C_{14}H_{14}O_3N_3SNa$.
An orange-yellow powder or crystalline scales, slightly soluble in cold water; insoluble in alcohol; readily soluble in hot water.

Methyl Orange Solution –Dissolve 0.1 g of methyl orange in 80 ml of water and dilute to 100 ml with alcohol.

Test for sensitivity –A mixture of 0.1 ml of the methyl orange solution and 100 ml freshly boiled and cooled water is yellow. Not more than 0.1 ml of 0.1 N hydrochloric acid is required to change the colour to red.

Colour change – pH 3.0 (red) to pH 4.4 (yellow).

Methyl Red – *p*-Dimethylaminoazobenzene-O-carboxylic acid, $C_{15}H_{15}O_2N_3$.

A dark red powder or violet crystals, sparingly soluble in *water*; soluble in alcohol.

Methyl red solution –Dissolve 100 mg in 1.86 ml of 0.1 N *sodium hydroxide* and 50 ml of *alcohol* and dilute to 100 ml with water.

Test for sensitivity –A mixture of 0.1 ml of the *methyl red solution* and 100 ml of freshly boiled and cooled *water* to which 0.05 ml of 0.02 N *hydrochloric acid* has been added is red. Not more than 0.01 ml of 0.02 N *sodium hydroxide* is required to change the colour to yellow.

Colour change – pH 4.4 (red) to pH 6.0 (yellow).

Methyl isobutyl ketone (MIBK) solution- 20% hydrochloric acid solution mixes with MIBK in 1:1 ratio. Transfer in separating funnel shake well to remove heavy metals present as impurities. Separated organic layer of MIBK.

Nitric Acid –Contains 70.0 per cent w/w of HNO_3 (limits, 69.0 to 71.0). About 16 N in strength.

Description –Clear, colourless, fuming liquid.

Wt. per ml. – At 20°, 1.41 to 1.42 g.

Copper and Zinc –Dilute 1 ml with 20 ml of water, and add a slight excess of dilute ammonia solution; the mixture does not become blue. Pass hydrogen sulphide; a precipitate is not produced.

Iron –0.5 ml of complies with the limit test for iron.

Lead –Not more than 2 parts per million.

Chloride –5 ml neutralised with dilute ammonia solution, complies with the limit test for chlorides.

Sulphates –To 2.5 ml add 10 mg of sodium bicarbonate and evaporate to dryness on a water-bath, the residue dissolved in water, complies with the limit test for sulphates.

Sulphated ash – Not more than 0.01 per cent w/w.

Assay –Weigh accurately about 4 g into a stoppered flask containing 40 ml of water, and titrate with N Sodium hydroxide, using methyl orange solution as indicator. Each ml of N sodium hydroxide is equivalent to 0.06301 g of HNO_3 .

Nitric Acid, xN –Solutions of any normality XN may be prepared by diluting 63x ml of nitric acid to 1000 ml with water.

Nitric Acid, Dilute –Contains approximately 10 per cent w/w of HNO_3 . Dilute 106 ml of nitric acid to 1000 ml with water.

Perchloric Acid- $\text{HClO}_4 = 100.46$

A solution in water containing between 70 percent and 72 percent w/v of HClO_4 and about 12 M in strength.

Clear, colourless liquid; very corrosive and may deflagrate on contact with oxidisable substances; wt. per ml, about

Phenolphthalein – $\text{C}_{20}\text{H}_{14}\text{O}_4$.

A white to yellowish-white powder, practically insoluble in water, soluble in alcohol.

Phenolphthalein Solution –Dissolve 0.10 g in 80 ml of *alcohol* and dilute to 100 ml with water.

Test for sensitivity –To 0.1 ml of the *phenolphthalein solution* add 100 ml of freshly boiled and cooled water, the solution is colourless. Not more than 0.2 ml of 0.02 N *sodium hydroxide* is required to change the colour to pink.

Colour change –pH 8.2 (colourless) to pH 10.0 (red)

Phosphoric Acid – $\text{H}_3\text{PO}_4 = 98.00$.

(Orthophosphoric Acid; Concentrated Phosphoric Acid).

Description – Clear and colourless syrupy liquid, corrosive.

Solubility – Miscible with water and with alcohol.

Phosphoric Acid, x N – Solutions of any normality, x N may be prepared by diluting 49 x g of *phosphoric acid* with water to 1000 ml.

Phosphoric Acid, Dilute – Contains approximately 10 per cent w/v of H_3PO_4 .

Dilute 69 ml of *phosphoric acid* to 1000 ml with water.

Potassium Chloride – $\text{KCl} = 74.55$

Potassium Chromate – $\text{K}_2\text{CrO}_4 = 194.2$

Potassium Chromate Solution – A 5.0 per cent w/v solution of potassium chromate. Gives a red precipitate with *silver nitrate* in neutral solutions.

Potassium Dichromate – $\text{K}_2\text{Cr}_2\text{O}_7 = 294.18$.

Contains not less than 99.8 per cent of $\text{K}_2\text{Cr}_2\text{O}_7$.

Description – Orange-red crystals or a crystalline powder.

Solubility – Soluble in *water*

Chloride – To 20 ml of a 5 per cent w/v solution in *water* and 10 ml *nitric acid*, warm to about 50° and add a few drops of *silver nitrate solution*; not more than a faint opalescence is produced.

Assay – Carry out the assay described under Potassium Chromate, using 2 g. Each ml of 0.1 N *sodium thiosulphate* is equivalent to 0.004904 g of $\text{K}_2\text{Cr}_2\text{O}_7$.

Potassium Dichromate Solution – A 7.0 per cent w/v solution of *potassium dichromate* in *water*.

Potassium Dichromate, Solution 0.1N – $\text{K}_2\text{Cr}_2\text{O}_7 = 294.18$, 4.903 g in 1000 ml.

Weigh accurately 4.903 g of *potassium dichromate* and dissolve in sufficient *water* to produce 1000 ml.

Potassium Dihydrogen Phosphate - $\text{KH}_2\text{PO}_4 = 136.1$

Potassium Ferrocyanide – $\text{K}_4\text{Fe}(\text{CN})_6 \cdot 3\text{H}_2\text{O} = 422.39$.

Contains not less than 99.0 per cent of $\text{K}_4\text{Fe}(\text{CN})_6 \cdot 3\text{H}_2\text{O}$.

Description –Yellow, crystalline powder.

Solubility –Soluble in water.

Acidity or Alkalinity –A 10 per cent w/v solution in water is neutral to litmus paper.

Assay –Weigh accurately about 1 g and dissolve in 200 ml of *water*, add 10 ml of *sulphuric acid* and titrate with 0.1 *N potassium permanganate*. Each ml of 0.1 *N potassium permanganate* is equivalent to 0.04224 g of $\text{K}_4\text{Fe}(\text{CN})_6 \cdot 3\text{H}_2\text{O}$.

Potassium Ferrocyanide Solution –A 5.0 per cent w/v solution of *potassium ferrocyanide* in *water*.

Potassium Hydrogen Phthalate – $\text{CO}_2\text{H} \cdot \text{C}_6\text{H}_4 \cdot \text{CO}_2\text{K}$ =204.22.

Contains not less than 99.9 per cent and not more than the equivalent of 100.1 per cent of $\text{C}_8\text{H}_5\text{O}_4\text{K}$ calculated with reference to the substance dried at 110° for one hour.

Description –White, crystalline powder.

Solubility –Slowly soluble in *water*, forming clear, colourless solution.

Acidity –A 2.0 per cent w/v solution in carbon dioxide free water gives with *bromophenol blue* solution the grey colour indicative of pH 4.0.

Assay –Weigh accurately about 9 g, dissolve in 100 ml of *water* and titrate with *N sodium hydroxide* using *phenolphthalein* solution as indicator. Each ml of *N Sodium hydroxide* is equivalent to 0.2042 g of $\text{C}_8\text{H}_5\text{O}_4\text{K}$.

Potassium Hydrogen Phthalate, 0.02 M – Dissolve 4.084 g of *Potassium hydrogen phthalate* in sufficient *water* to produce 1000 ml.

Potassium Hydrogen Phthalate, 0.2 M – Dissolve 40.84 g of *potassium hydrogen phthalate* in sufficient *water* to produce 1000 ml.

Potassium Hydroxide –Caustic Potash : KOH = 56.11

Contains not less than 85.0 per cent of total alkali, calculated as KOH and not more than 4.0 per cent of K_2CO_3 .

Description – Dry white sticks, pellets or fused mass; hard, brittle and showing a crystalline fracture; very deliquescent; strongly alkaline and corrosive.

Solubility –Freely soluble in *water*, in *alcohol* and in *glycerin*; very soluble in boiling *ethyl alcohol*.

Aluminium, iron and matter insoluble in *hydrochloric acid* –Boil 5 g with 40 ml of dilute *hydrochloric acid*, cool, make alkaline with dilute ammonia solution, boil, filter and wash the residue with a 2.5 per cent w/v solution of ammonium nitrate; the insoluble residue, after ignition to constant weight, weighs not more than 5 mg.

Chloride –0.5 g dissolved in water with the addition of 1.6 ml of nitric acid, complies with the limit test for chlorides.

Heavy metals –Dissolve 1 g in a mixture of 5 ml of water and 7 ml of dilute hydrochloric acid. Heat to boiling, add 1 drop of phenolphthalein solution and dilute ammonia solution dropwise to produce a faint pink colour. Add 2 ml of acetic acid and water to make 25 ml; the limit of heavy metals is 30 parts per million.

Sulphate –Dissolve 1 g in water with the addition of 4.5 ml of hydrochloric acid; the solution complies with the limit test for sulphates.

Sodium –To 3 ml of a 10 per cent w/v solution add 1 ml of water, 1.5 ml of alcohol, and 3 ml of potassium antimonate solution and allow to stand; no white crystalline precipitate or sediment is visible to the naked eye within fifteen minutes.

Assay –Weigh accurately about 2 g, and dissolve in 25 ml of water, add 5 ml of barium chloride solution, and titrate with N hydrochloric acid, using phenolphthalein solution as indicator. To the solution in the flask add bromophenol blue solution, and continue the titration with N hydrochloric acid. Each ml of N hydrochloric acid, used in the second titration is equivalent to 0.06911 g of K_2CO_3 . Each ml of N hydrochloric acid, used in the combined titration is equivalent to 0.05611 g of total alkali, calculated as KOH.

Storage –Potassium Hydroxide should be kept in a well-closed container.

Potassium Hydroxide, xN – *Solution of any normality, $x N$, may be prepared by dissolving 56.11x g of potassium hydroxide in water and diluting to 1000 ml.*

Potassium Hydroxide Solution – *Solution of Potash.*

An aqueous solution of potassium hydroxide containing 5.0 per cent w/v of total alkali, calculated as KOH (limits, 4.75 to 5.25).

Assay –Titrate 20 ml with N sulphuric acid, using solution of methyl orange as indicator. Each ml of N sulphuric acid is equivalent to 0.05611 g of total alkali, calculated as KOH.

Storage –Potassium hydroxide solution should be kept in a well-closed container of lead-free glass or of a suitable plastic.

Potassium Iodide – $KI = 166.00$

Description – Colourless crystals or white powder; odourless, taste, saline and slightly bitter.

Solubility –Very soluble in water and in glycerin; soluble in alcohol.

Arsenic –Not more than 2 parts per million.

Heavy metals -Not more than 10 parts per million, determined on 2.0 g by Method A.

Barium –Dissolve 0.5 g in 10 ml of water and add 1 ml of dilute sulphuric acid; no turbidity develops within one minute.

Cyanides –Dissolve 0.5 g in 5 ml of warm water, add one drop of ferrous sulphate solution and 0.5 ml of sodium hydroxide solution and acidify with hydrochloric acid; no blue colour is produced.

Iodates –Dissolve 0.5 g in 10 ml of freshly boiled and cooled water, and add 2 drops of dilute sulphuric acid and a drop of starch solution; no blue colour is produced within two minutes.

Assay –Weigh accurately about 0.5 g, dissolve in about 10 ml of water and add 35 ml of hydrochloric acid and 5 ml of chloroform. Titrate with 0.05 M potassium iodate until the purple colour of iodine disappears from the chloroform. Add the last portion of the iodate solution drop-wise and agitate vigorously and continuously. Allow to stand for five minutes. If any colour develops in the chloroform layer continue the titration. Each ml of 0.05 M potassium iodate is equivalent to 0.0166 mg of KI.

Storage –Store in well-closed containers.

Potassium Iodide, M –Dissolve 166.00 g of potassium iodide in sufficient water to produce 1000 ml.

Potassium Iodide and Starch Solution – Dissolve 10 g of potassium iodide in sufficient water to produce 95 ml and add 5 ml of starch solution.

Potassium Iodide and Starch solution must be recently prepared.

Potassium Iodide Solution –A 10 per cent w/v solution of potassium iodide in water.

Potassium Permanganate – $\text{KMnO}_4 = 158.03$

Description –Dark purple, slender, prismatic crystals, having a metallic lustre, odourless; taste, sweet and astringent.

Solubility –Soluble in *water*; freely soluble in *boiling water*.

Chloride and Sulphate –Dissolve 1 g in 50 ml of boiling *water*, heat on a water-bath, and add gradually 4 ml or a sufficient quantity of *alcohol* until the meniscus is colour-less; filter. A 20 ml portion of the filtrate complies with the limit test for *chloride*, Appendix 2.3.2., and another 20 ml portion of the filtrate complies with the limit test for *sulphates*.

Assay – Weigh accurately about 0.8 g, dissolve in water and dilute to 250 ml. Titrate with this solution 25.0 ml of 0.1 *N oxalic acid* mixed with 25 ml of *water* and 5 ml of *sulphuric acid*. Keep the temperature at about 70° throughout the entire titration. Each ml of 0.1 *N oxalic acid* is equivalent to 0.00316 g of KMnO_4 .

Storage – Store in well-closed containers.

Caution – Great care should be observed in handling *potassium permanganate*, as dangerous explosions are liable to occur if it is brought into contact with organic or other readily oxidisable substance, either in solution or in the dry condition.

Potassium Permanganate Solution – A 1.0 per cent w/v solution of *potassium permanganate* in water.

Potassium Permanganate, 0.1 N Solution – 158.03. 3.161 g in 1000 ml

Dissolve about 3.3 g of *potassium permanganate* in 1000 ml of *water*, heat on a water-bath for one hour and allow to stand for two days. Filter through glass wool and standardise the solution as follows :

To an accurately measured volume of about 25 ml of the solution in a glass stoppered flask add 2 g of *potassium iodide* followed by 10 ml of *N sulphuric acid*. Titrate the liberated *iodine* with standardised 0.1 *N sodium thiosulphate*, adding 3 ml of *starch solution* as the end point is approached. Correct for a blank run on the same quantities of the same reagents. Each ml of 0.1 *N sodium thiosulphate* is equivalent to 0.003161 g of KMnO_4 .

Potassium Per Iodate – Analytical grade

Potassium Pyro Sulphate – Analytical grade

Patterns and Reeders indicator – Dissolve 0.10 g indicators in 100 ml of methanol.

Purified Water – H_2O = 18.02.

Description – Clear, colourless liquid, odourless, tasteless.

Purified water is prepared from potable water by distillation, ion-exchange treatment, reverse osmosis or any other suitable process. It contains no added substances.

pH – Between 4.5 and 7.0 determined in a solution prepared by adding 0.3 ml of a saturated solution of *potassium chloride* to 100 ml of the liquid being examined.

Carbon dioxide – To 25 ml add 25 ml of *calcium hydroxide solution*, no turbidity is produced.

Chloride – To 10 ml add 1 ml of *dilute nitric acid* and 0.2 ml of *silver nitrate solution*; no opalescence is produced.

Sulphate –To 10 ml add 0.1 ml of *dilute hydrochloric acid* and 0.1 ml of *barium chloride*.

Solution : the solution remains clear for an hour.

Nitrates and Nitrites –To 50 ml add 18 ml of *acetic acid* and 2 ml of *naphthylamine-sulphanilic acid* reagent. Add 0.12 g of *zinc reducing mixture* and shake several times. No pink colour develops within fifteen minutes.

Ammonium – To 20 ml add 1 ml of *alkaline potassium mercuric-iodide solution* and after five minutes view in a Nessler cylinder placed on a white tile; the colour is not more intense than that given on adding 1 ml of *alkaline potassium mercuric-iodide solution* to a solution containing 2.5 ml of *dilute ammonium chloride solution* (Nessler's) 7.5 ml of the liquid being examined.

Calcium –To 10 ml add 0.2 ml of *dilute ammonia solution* and 0.2 ml of *ammonium oxalate solution*; the solution remains clear for an hour.

Heavy metals –Adjust the pH of 40 ml to between 3.0 and 4.0 with *dilute acetic acid*, add 10 ml of freshly prepared *hydrogen sulphide solution* and allow to stand for ten minutes; the colour of the solution is not more than that of a mixture of 50 ml of the liquid being examined and the same amount of *dilute acetic acid* added to the sample.

Oxidisable matter –To 100 ml add 10 ml of *dilute sulphuric acid* and 0.1 ml of 0.1 N *potassium permanganate* and boil for five minutes. The solution remains faintly pink.

Total Solids –Not more than 0.001 per cent w/v determined on 100 ml by evaporating on a water bath and drying in an oven at 105⁰ for one hour.

Storage –Store in tightly closed containers.

Safranin solution – 1% in 70% alcohol.

Silver Nitrate Solution – A freshly prepared 5.0 per cent w/v solution of silver nitrate in water.

Silver Nitrate, 0.1 N– $\text{AgNO}_3 = 169.87$; 16.99 g in 1000 ml. Dissolve about 17 g in sufficient *water* to produce 1000 ml and standardise the solution as follows:

Weigh accurately about 0.1 g of *sodium chloride* previously dried at 110⁰ for two hours and dissolve in 5 ml of *water*. Add 5 ml of *acetic acid*, 50 ml of *methyl alcohol* and three drops of *eosin solution* is equivalent to 1 ml of 0.1 N *silver nitrate*.

Sodium fluoride – $\text{NaF} = 41.99$

Description – White powder or colourless crystals.

Solubility – Soluble in *water*; practically insoluble in *ethanol* (95%).

Storage - Store in well-closed containers.

Standards – Sodium Fluoride contains not less than 98.5 per cent and not more than 100.5 per cent of NaF, calculated with reference to the dried substance.

Identification – A: Dissolve 2.5 g in sufficient carbon dioxide-free water without heating to produce 100 ml (solution A). To 2 ml of solution A add 0.5 ml of calcium chloride solution; a gelatinous white precipitate is produced which dissolves on adding 5 ml of ferric chloride solution.

B: Add about 4 mg to a mixture of 0.1 ml of alizarin red S solution and 0.1 ml of zirconyl nitrate solution and mix; the colour changes to yellow.

Sodium peroxide - Na_2O_2

Contains not less than 85.0% of Na_2O_2 .

Description –A yellowish powder or granules, hygroscopic.

Solubility- Readily soluble in water, with evolution of oxygen.

Assay- Weigh accurately about 0.2 g, into a dry flask, add a mixture of 10 ml of solution of potassium iodide, 10 ml of *dilute hydrochloric acid* and 10 ml of water and titrate the liberated iodine with 0.1N sodium thiosulphate. Each ml of 0.1N sodium thiosulphate is equivalent to 0.0039 g of Na_2O_2 .

Sodium Bicarbonate – NaHCO_3 =84.01

Description –White, crystalline powder or small, opaque, monoclinic crystals; odourless; taste, saline.

Solubility –Freely soluble in *water*; practically insoluble in *alcohol*.

Carbonate –pH of a freshly prepared 5.0 per cent w/v solution in *carbon dioxide-free water*, not more than 8.6.

Aluminium, calcium and insoluble matter –Boil 10 g with 50 ml of *water* and 20 ml of *dilute ammonia solution*, filter, and wash the residue with *water*; the residue, after ignition to constant weight, not more than 1 mg.

Arsenic –Not more than 2 parts per million.

Iron –Dissolve 2.5 g in 20 ml of *water* and 4 ml of *iron-free hydrochloric acid*, and dilute to 40 ml with *water*; the solution complies with the *limit test for iron*.

Heavy metals –Not more than 5 parts per million, determined by Method A on a solution prepared in the following manner:

Mix 4.0 g with 5 ml of *water* and 10 ml of *dilute hydrochloric acid*, heat to boiling, and maintain the temperature for one minute. Add one drop of *phenolphthalein solution* and sufficient *ammonia solution* drop wise to give the solution a faint pink colour. Cool and dilute to 25 ml with *water*.

Chlorides –Dissolve 1.0 g in *water* with the addition of 2 ml of *nitric acid*; the solution complies with the *limit test for chlorides*.

Sulphates –Dissolve 2 g in *water* with the addition of 2 ml of *hydrochloric acid*; the solution complies with the limit test for *sulphate*.

Ammonium compounds –1 g warmed with 10 ml of *sodium hydroxide solution* does not evolve ammonia.

Assay –Weigh accurately about 1 g, dissolve in 20 ml of *water*, and titrate with 0.5 *N sulphuric acid* using *methyl orange solutions* as indicator. Each ml of 0.5 *N sulphuric acid* is equivalent to 0.042 g of NaHCO_3 .

Storage –Store in well-closed containers.

Sodium Bicarbonate Solution –A 5 per cent w/v solution of *sodium bicarbonate* in *water*.

Sodium Carbonate – $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} = 286.2$.

Sodium Chloride – $\text{NaCl} = 58.44$

Sodium fluoride –

Sodium Hydroxide – $\text{NaOH} = 40.00$

Description –White sticks, pellets, fused masses, or scales; dry, hard brittle and showing a crystalline fracture, very deliquescent; strongly alkaline and corrosive.

Solubility –Freely soluble in *water* and in *alcohol*.

Aluminium, iron and matter insoluble in hydrochloric acid –Boil 5 g with 50 ml of dilute hydrochloric acid, cool, make alkaline with *dilute ammonia solution*, boil, filter, and wash with a 2.5 per cent w/v solution of *ammonium nitrate*; the insoluble residue after ignition to constant weight weighs not more than 5 mg.

Arsenic –Not more than 4 parts per million.

Heavy metals –Not more than 30 parts per million, determined by Method A, Appendix 2.3.3. in a solution prepared by dissolving 0.67 g in 5 ml of *water* and 7 ml of 3 *N hydrochloric acid*. Heat to boiling, cool and dilute to 25 ml with *water*.

Potassium –Acidify 5 ml of a 5 per cent w/v solution with *acetic acid* and add 3 drops of *sodium cobaltinitrite solution*; no precipitate is formed.

Chloride – 0.5 g dissolved in *water* with the addition of 1.8 ml of *nitric acid*, complies with the limit test for *chlorides*.

Sulphates –1 g dissolved in *water* with the addition of 3.5 ml of *hydrochloric acid* complies with the limit test for *sulphates*.

Assay –Weigh accurately about 1.5 g and dissolve in about 40 ml of *carbon dioxide-free water*. Cool and titrate with *N sulphuric acid* using *phenolphthalein solution* as indicator. When the pink colour of the solution is discharged, record the volume of acid solution required, add *methyl orange solution* and continue the titration until a persistent pink colour is produced. Each ml of *N sulphuric acid* is equivalent to 0.040 g of total alkali calculated as NaOH and each ml of acid consumed in the titration with *methyl orange* is equivalent to 0.106 g of Na_2CO_3 .

Storage –Store in tightly closed containers.

Sodium Hydroxide, xN – Solutions of any normality, xN may be prepared by dissolving 40 x g of *sodium hydroxide* in *water* and diluting to 1000 ml.

Sodium Hydroxide Solution – A 20.0 per cent w/v solution of *sodium hydroxide* in *water*.

Sodium Hydroxide Solution, Dilute – A 5.0 per cent w/v solution of *sodium hydroxide* in *water*.

Sodium Potassium Tartrate –Rochelle Salt $\text{COONa} \cdot \text{CH}(\text{OH}) \cdot \text{CH}(\text{OH}) \cdot \text{COOK} \cdot 4\text{H}_2\text{O} = 282.17$

Contains not less than 99.0 per cent and not more than the equivalent of 104.0 per cent of $\text{C}_4\text{H}_4\text{O}_6\text{KNa} \cdot 4\text{H}_2\text{O}$.

Description –Colourless crystals or a white, crystalline powder; odourless; taste saline and cooling. It effloresces slightly in warm, dry air, the crystals are often coated with a white powder.

Solubility –Soluble in *water*; practically insoluble in alcohol.

Acidity or Alkalinity –Dissolve 1 g in 10 ml of recently boiled and cooled *water*, the solution requires for neutralisation not more than 0.1 ml of 0.1 *N sodium hydroxide* or of 0.1 *N hydrochloric acid*, using *phenolphthalein solution* as indicator.

Iron –0.5 g complies with the *limit test for iron*.

Chloride –0.5 g complies with the *limit test for chloride*.

Sulphate –0.5 g complies with the *limit test for sulphate*.

Assay –Weigh accurately about 2 g and heat until carbonised, cool, and boil the residue with 50 ml of *water* and 50 ml of 0.5 N *sulphuric acid*; filter, and wash the filter with *water*; titrate the excess of acid in the filtrate and washings with 0.5 N *sodium hydroxide*, using *methyl orange solution* as indicator. Each ml of 0.5 N *sulphuric acid* is equivalent to 0.07056 g of $\text{C}_4\text{H}_4\text{O}_6\text{KNa} \cdot 4\text{H}_2\text{O}$.

Sodium Thiosulphate – $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O} = 248.17$.

Description – Large colourless crystals or coarse, crystalline powder; odourless; taste, saline, deliquescent in moist air and effloresces in dry air at temperature above 33° .

Solubility – Very soluble in *water*; insoluble in *alcohol*.

pH –Between 6.0 and 8.4, determined in a 10 per cent w/v solution.

Arsenic –Not more than 2 parts per million.

Heavy metals –Not more than 20 parts per million, determined by Method A, Appendix 2.3.3. in a solution prepared in the following manner : Dissolve 1 g in 10 ml of *water*, slowly add 5 ml of *dilute hydrochloric acid* and evaporate the mixture to dryness on a water-bath. Gently boil the residue with 15 ml of *water* for two minutes, and filter. Heat the filtrate to boiling, and add sufficient *bromine solution* to the hot filtrate to produce a clear solution and add a slight excess of *bromine solution*. Boil the solution to expel the *bromine* completely, cool to room temperature, then add a drop of *phenolphthalein solution* and *sodium hydroxide solution* until a slight pink colour is produced. Add 2 ml of *dilute acetic acid* and dilute with *water* to 25 ml.

Calcium –Dissolve 1 g in 20 ml of *water*, and add a few ml of *ammonium oxalate solution*; no turbidity is produced.

Chloride –Dissolve 0.25 g in 15 ml of 2N *nitric acid* and boil gently for three to four minutes, cool and filter; the filtrate complies with the *limit test for chlorides*.

Sulphate and Sulphite –Dissolve 0.25 g in 10 ml of *water*, to 3 ml of this solution add 2 ml of *iodine solution*, and gradually add more *iodine solution*, dropwise until a very faint-persistent yellow colour is produced; the resulting solution complies with the limit test for sulphates.

Sulphide –Dissolve 1 g in 10 ml of *water* and 10.00 ml of a freshly prepared 5 per cent w/v solution of *sodium nitroprusside*; the solution does not become violet.

Assay –Weigh accurately about 0.8 g and dissolve in 30 ml of *water*. Titrate with 0.1 N *iodine*, using 3 ml of *starch solution* as indicator as the end-point is approached. Each ml of 0.1 *iodine* is equivalent to 0.02482 g of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$.

Storage –Store in tightly-closed containers.

Sodium Thiosulphate 0.1 N –24.82 g in 1000 ml.

Dissolve about 26 g of *sodium thiosulphate* and 0.2 g of *sodium carbonate* in *carbon dioxide-free water* and dilute to 1000 ml with the same solvent. Standardise the solution as follows :

Dissolve 0.300 g of *potassium bromate* in sufficient *water* to produce 250 ml. To 50 ml of this solution, add 2 g of *potassium iodide* and 3 ml of 2 N *hydrochloric acid* and titrate with the *sodium-thiosulphate solution* using *starch solution*, added towards the end of the titration, as indicator until the blue colour is discharged. Each 0.002784 g of *potassium bromate* is equivalent to 1 ml of 0.1N *sodium thiosulphate*. Note: –Re-standardise 0.1 N *sodium thiosulphate* frequently.

Stannous Chloride – $\text{SnCl}_2 \cdot 2\text{H}_2\text{O} = 225.63$.

Contains not less than 97.0 per cent of $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$.

Description –Colourless crystals.

Solubility –Soluble in *dilute hydrochloric acid*.

Arsenic- Dissolve 5.0 g in 10 ml of *hydrochloric acid*, heat to boiling and allow to stand for one hour; the solution shows no darkening when compared with a freshly prepared solution of 5.0 g in 10 ml of *hydrochloric acid*.

Sulphate –5.0 g with the addition of 2 ml of *dilute hydrochloric acid*, complies with the *limit test for sulphates*.

Assay –Weigh accurately about 1.0 g and dissolve in 30 ml of *hydrochloric acid* in a stoppered flask. Add 20 ml of *water* and 5 ml of *chloroform* and titrate rapidly with 0.05 M *potassium iodate* until the *chloroform* layer is colourless. Each ml of 0.05 M *potassium iodate* is equivalent to 0.02256 g of $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$.

Stannous Chloride Solution – May be prepared by either of the two methods given below :

Dissolve 330 g of *stannous chloride* in 100 ml of *hydrochloric acid* and add sufficient *water* to produce 1000 ml.

Dilute 60 ml of *hydrochloric acid* with 20 ml of *water*, add 20 g of tin and heat gently until gas ceases to be evolved; add sufficient *water* to produce 100 ml, allowing the undissolved tin to remain in the solution.

Starch Soluble – Starch, which has been treated with *hydrochloric acid* until after being washed, it forms an almost clear liquid solution in hot water.

Description –Fine, white powder.

Solubility –Soluble in hot *water*, usually forming a slightly turbid *solution*.

Acidity or Alkalinity –Shake 2 g with 20 ml of *water* for three minutes and filter; the filtrate is not alkaline or more than faintly acid to litmus paper.

Sensitivity –Mix 1 g with a little cold *water* and add 200 ml *boiling water*. Add 5 ml of this solution to 100 ml of *water* and add 0.05 ml of 0.1 *N iodine*. The deep blue colour is discharged by 0.05 ml of 0.1 *N sodium thiosulphate*.

Ash – Not more than 0.3 per cent.

Starch Solution –Triturate 0.5 g of *soluble starch*, with 5 ml of *water*, and add this, with constant stirring, to sufficient water to produce about 100 ml. Boil for a few minutes, cool, and filter.

Solution of *starch must be recently prepared*.

Sulphuric Acid – $\text{H}_2\text{SO}_4 = 98.08$.

When no molarity is indicated use of commerce containing about 98 per cent w/w of *sulphuric acid*. An oily, corrosive liquid weighing about 1.84 g per ml and about 18 M in strength.

When solutions of molarity xM are required, they should be prepared by carefully adding 54 ml of sulphuric acid to an equal volume of water and diluting with water to 1000 ml.

Solutions of sulphuric acid contain about 10 per cent w/v of H_2SO_4 per g mol.

Sulphuric Acid, Dilute –Contains approximately 10 per cent w/w of H_2SO_4 .

Dilute 57 ml of sulphuric acid to 1000 ml with water.

Sulphuric Acid, Chlorine-free –Sulphuric acid which complies with the following additional test:

Chloride –Mix 2 ml with 50 ml of water and add 1 ml of solution of *silver nitrate*, no opalescence is produced.

Sulphuric Acid, Nitrogen-free–Sulphuric acid which contains not less than 98.0 per cent w/w of H_2SO_4 and complies with the following additional test :

Nitrate –Mix 45 ml with 5 ml of *water*, cool and add 8 mg of *diphenyl benezidine*; the solution is colourless or not more than very pale blue.

Triethanolamine 20% solution – 200 ml of tri-ethanolamine, add 800 ml water and make up to 1000 ml

Thio Urea - $\text{H}_2\text{N}.\text{CS}.\text{NH}_2$

Contains not less than 99.0 percent of $\text{CH}_4\text{N}_2\text{S}$, calculated with reference to the substance dried to constant weight at 105° .

Urea – $\text{H}_2\text{N.CO.NH}_2$, Analytical grade reagent of commerce

Water –See purified water.

Water, Ammonia-free –Water, which has been boiled vigorously for a few minutes and protected from the atmosphere during cooling and storage.

Xylenol Orange – [3H-2,1-Benzoxathiol-3-ylidene bis – (6-hydroxy-5-methyl-m-phenylene) methylenenitrilo] tetra acetic acid SS-dioxide or its tetra sodium salt.

Gives a reddish-purple colour with mercury, lead, zinc and contain other metal ions in acid solution. When metal ions are absent, for example, in the presence of an excess of *disodium ethylenediamine tetraacetate*, this solution is yellow.

Xylenol Orange Solution –Dissolve 0.1 g of *xylenol orange* with 100 ml of *water* and filter, if necessary.

Zinc Acetate – Analytical grade reagent of commerce.

APPENDIX - 5
Classical Ayurvedic References

5. CLASSICAL AYURVEDIC REFERENCES

Abhraka (अभ्रक)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 53

स्निग्धं पृथुदलं वर्णसंयुक्तं भारतोऽधिकम् ।

सुखनिर्मोच्यपत्रं च तदभ्रं शस्तमीरितम् ॥

(र.र.स. 2/11)

नीलाञ्जनोपमं स्निग्धं भारपूर्णं महोज्ज्वलम् ।

निर्मोच्यपत्रं मृदुलं त्वभ्रं श्रेष्ठमिहोच्यते ॥

(र.त. 10/13)

वज्रं तु वज्रवत्तिष्ठेन्न चाग्नौ विकृतिं व्रजेत् ।

सर्वाभ्रेषु वरं वज्रं व्याधिवार्धक्यमृत्युजित् ॥

यदञ्जननिभं क्षिप्तं न वह्नौ विकृतिं व्रजेत् ।

वज्रसंज्ञं हि तद्योग्यमभ्रं सर्वत्र नेतरत् ॥

(आ.प्र. 2/97-98)

अभ्रकं वह्निसन्तप्तं सप्तवारं निषेचितम् ।

गोदुग्धे वा वराकवाथे शुद्धिमायात्यनुत्तमाम् ॥

(र.त. 10/20)

Akīka (अकीक)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 82

Gairika (गैरिक)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 51

यूनानी द्रव्यगुणादर्श, खण्ड -3, वैद्य हकीम दलजीत सिंह
पृष्ठ 249

अत्यन्तशोणितं स्निग्धं मसृणं स्वर्णगैरिकम् ।

(र.र.स. 3/46)

सुवर्णगैरिकं स्निग्धं मसृणं त्वतिकोमलम् ।

पाषाणगैरिकं रूक्षं कठिनं नातिलोहितम् ॥

(र.त. 22/112)

गैरिकं तु गवां दुग्धैर्भावितं शुद्धिमृच्छति ॥

(र.र.स. 3/49)

सुवर्णगैरिकं स्निग्धं मधुरं शिशिरं परम् ।

तुवरं तापहरणं हिक्कावमिनिवारणम् ॥

रक्तपित्तप्रशमनं तथासृग्दरनाशनम् ।

विषापहं तथा बल्यं मतं लोचनयोर्हितम् ॥

उदरकण्डूशमनं तथैव व्रणरोपणम् ।

ज्वरघ्नं च विशेषेण वह्निदाहनिर्बर्हणम् ॥

(र.त.22/116-118)

स्वादु स्निग्धं हिमं नेत्र्यं कषायं रक्तपित्तनुत् ।

हिध्मावमिविषघ्नं च रक्तघ्नं स्वर्णगैरिकम् ॥

(र.र.स. 3/47)

गैरिकद्वितयं स्निग्धं मधुरं तुवरं हिमम् ।

चक्षुष्यं दाहपित्तास्रकफहिक्काविषापहम् ॥

(आ.प्र. 2/270)

गैरिकं मधुरं शीतं कषायं व्रणरोपणम् ॥
विस्फोटार्शोऽग्निदाहघ्नं कण्डूवीसर्पनाशनम् ।
स्वादु स्निग्धं हिमं नेत्र्यं कषायं रक्तपित्तनुत् ॥

(रसामृतम् 3/165-167)

द्विगुञ्जतः समारभ्य चतुर्गुञ्जमितं परम् ।
सुवर्णगैरिकं शुद्धं युञ्जीत भिषजां वरः ॥

(र.त. 22/119)

Gandhaka (गन्धक)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 14

शुकपिच्छसमच्छायो नवनीतसमप्रभः ।
मसृणः कठिनः स्निग्धः श्रेष्ठो गन्धक उच्यते ॥

(आ.प्र. 2/20)

निर्मलस्तु रजनीसमप्रभो दीप्तिमांश्च नवनीतकोमलः ।
कीर्तितो ह्यमलसारसंज्ञको गन्धको रसरसायने वरः ॥

(र.त.8/4)

गव्ये पयसि गन्धं तु भृङ्गराजरसेऽथवा ।
रसपर्पटिकाप्रोक्तविधानेन विशोधयेत् ॥

(रसामृतम् 2/3)

गन्धाश्मातिरसायनः समधुरः पाके कटूष्णान्वितः
कण्डूकुष्ठविसर्पदद्गुदमनो दीप्तानलः पाचनः ।
आमोन्मोचनशोषणो विषहरः सूतेन्द्रवीर्यप्रदः
गौरीपुष्पभवस्तथा क्रिमिहरः सत्त्वात्मकः सूतजित् ॥

(र.चू. 11/5)

विपाके मधुरो गन्धपाषाणस्तु रसायनः ।

विसर्पकण्डुकुष्ठानां शमनो दीपनस्तथा ॥

(र.प्र.सु. 6/37)

गन्धको मधुरः पाके कटुरुष्णो रसायनः ॥

पाचनो दीपनो वृष्यः कृमिकुष्ठविनाशनः ।

योगवाही सरः स्निग्धः कफवातरुजापहः ॥

(रसामृतम् 2/1-2)

गन्धकः कटुकस्तिक्तो वीर्योष्णस्तुवरो रसः ।

पित्तलः कटुकः पाके कण्डूवीसर्पजन्तुजित् ॥

हन्ति कुष्ठं क्षयं प्लीहकफवातान् रसायनः ।

(आ.प्र. 2/15-16)

रक्तिकातः समारभ्य रक्तिकाष्टकसम्मितम् ।

प्राणाचार्यः प्रयुञ्जीत गन्धकं तु विशोधितम् ॥

(र.त. 8/39)

Godantī (गोदन्ती)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 62

पत्राचितं सुमसृणं शरदिन्दुसुनिर्मलम् ।

दीप्तप्रभं तु गोदन्तं ग्राह्यमत्र प्रकीर्तितम् ॥

(र.त. 11/238)

गोदन्तं निम्बुनीरेण द्रोणपुष्पीरसेन वा ।

यामार्द्धेनैव सुस्विन्नं विशुद्ध्यति न संशयः ॥

(र.त. 11/239)

Gomeda (गोमेद)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 77

गोमूत्राभं स्निग्धममन्दं समगात्रं
हेमारक्तं निर्दलमच्छं गुरुभारम् ।
दीप्तच्छायं मञ्जुलरूपं मसृणं यद्
गोमेदाख्यं रत्नमिह स्यात्तज्जात्यम् ॥

(र.त.23/121)

सत्रासं विगतच्छायं चिपिटं मलिनप्रभम् ।
सदलं लघु रूक्षं च गोमेदं हेयमीरितम् ॥

(र.त. 23/122)

निम्बूकस्वरसेनेह दोलायन्त्रे विधानतः ।
परिस्विन्नं तु यामैकं शुद्धिमायात्यनुत्तमाम् ॥

(र.त. 23/123)

Jaharamoharā (जहरमोहरा)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 65

Kānta Lauha (कान्त लौह)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 55

यूनानी द्रव्यगुणादर्श, खण्ड -3, वैद्य हकीम दलजीत सिंह
पृष्ठ 205

पात्रे यस्य प्रसरति जले तैलबिन्दुर्न लिप्तम् ।
गन्धं हिङ्गु त्यजति च तथा तिक्ततां निम्बकल्कः ।

पाके दुग्धं भवति शिखराकारकं नैति भूमौ ।
कान्तं लौहं तदिदमुदितं लक्षणोक्तं च नान्यत् ॥

(र.र.स. 5/95)

स्वर्णतारारताम्रायःपत्राण्यग्नौ प्रतापयेत् ।
निषिञ्चेत्तप्ततप्तानि तैले तक्त्रे च काञ्जिके ॥
गोमूत्रे च कुलत्थानां कषाये च त्रिधा त्रिधा ।

(शा.सं.मध्यम खण्ड 1-2½)

वराकषायसंयुते समे गवान्तु मूत्रके ।
निषेचितं तु सप्तधा त्वयो विशुद्धिमाप्नुयात् ॥

(र.त. 20/18)

Kāśīśa (काशीश)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 49

चूर्णकासीसकं श्वेतमीषत्पीतञ्च कीर्तितम् ।
पुष्पकासीसकं स्वच्छं हरिद्वर्णं प्रकीर्तितम् ॥

(र.त. 21/229)

काशीशं भृङ्गनीरेण त्रिवारं भावितं शुचि ।

(रसामृत 3/158)

कासीसद्वयमम्लोष्णं तिक्तं च तुवरं तथा ।
वातश्लेष्महरं केश्यं नेत्र्यं कण्डूविषप्रणुत् ॥
मूत्रकृच्छ्राश्मरीशिवत्रनाशनं परिकीर्तितम् ।
सकृद्भृङ्गाम्बुना स्विन्नं कासीसं निर्मलं भवेत् ॥

(आ.प्र. 2/274-275)

कासीसमम्लं तुवरमुष्णं च कचरञ्जनम् ॥

बल्यं नेत्र्यं विषशिवत्रपाण्डुप्लीहविनाशनम् ।

(रसामृतम् 3/156-157½)

क्षाराम्लं गुरुधूमाभं सोष्णवीर्यं विषापहम् ।

बालुकापूर्वकासीसं शिवत्रघ्नं केशरञ्जनम् ॥

पुष्पादिकासीसमतिप्रसिद्धं सोष्णं कषायाम्लमतीव नेत्र्यम् ।

विषानिलश्लेष्मगदव्रणघ्नं शिवत्रक्षयघ्नं कचरञ्जनं च ॥

(र.चू. 11/78-79)

क्षाराम्लागुरुधूमाभं सोष्णवीर्यं विषापहम् ।

बालुकापूर्वकासीसं शिवत्रघ्नं केशरञ्जनम् ॥

पुष्पादिकासीसमतिप्रशस्तं सोष्णं कषायाम्लमतीव नेत्र्यम् ।

विषानिलश्लेष्मगदव्रणघ्नं शिवत्रक्षयघ्नं कचरञ्जनं च ॥

(र.र.स. 3/52-53)

काशीशं भृङ्गनीरेण त्रिवारं भावितं शुचि ॥

(रसामृतम् 3/158)

गुञ्जार्द्धतः समारभ्य रक्तिकाद्वितयोन्मिता ।

कासीसकस्य कथिता पूर्णमात्रा भिषग्वरैः ।

(र.त. 21/242)

Khaṭikā (खटिका)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 61

खटिका द्विविधा ख्याता खटी गौरखटी तथा ।

खटी तु मलिना चान्या श्वेता मृदुशिलोपमा ॥

(र.त. 11/209)

खटीचूर्ण शुद्धपात्रे निधाय विमले जले ।
प्रक्षालयेद्विधानज्ञो विशुद्ध्यति न संशयः ॥

(र.त. 11/210)

खटिका शिशिरा तिक्ता मधुरा शोथनाशिनी ।
पित्तप्रशमनी कामं विविधव्रणरोपणी ॥
कफदाहास्रदोषघ्नी नेत्रामयनिषूदिनी ।
हरिद्वर्णातिसारघ्नी स्वेदादिस्रावहारिणी ॥

(र.त. 11/211-212)

खटिका मधुरा तिक्ता शीतला पित्तदाहनुत् ।
व्रणदोषकफास्रघ्नी ग्राहिणी नेत्ररोगनुत् ॥

(रसामृतम् 5/3- 4)

माषोन्मितं खटीचूर्णं भक्षितं शीतवारिणा ॥

(र.त. 11/213)

Maṇḍūra (मण्डूर)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 47

यूनानी द्रव्यगुणादर्श, खण्ड - 3, वैद्य हकीम दलजीत सिंह
पृष्ठ 249

षष्टिवर्षीयमधमं मध्यं सप्ततिवार्षिकम् ।
सर्वश्रेष्ठं समाख्यातं मण्डूरं शतवार्षिकम् ॥

(र.त. 20/125)

स्निग्धं गुरु दृढं चैव कृष्णं कोटरवर्जितम् ।
जीर्णं नष्टपुरःस्थञ्च मण्डूरं ग्राह्यमुच्यते ।

(र.त. 20/126)

ध्मातं बिभीतकाङ्गारैर्गोमूत्रे परिषेचितम् ।

सप्तवारं लोहमलं शुद्धिमायात्यनुत्तमाम् ॥

(र.त. 20/127)

Rajata (रजत)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ - 20

छेदे निकाषफलके दहने प्रकामं

रम्यञ्च शारदकलाधरमण्डलाभम् ।

नाराचिकाधृतमलं गुरुतामुपेयात्

स्निग्धं तदेव कथितं रजतन्तु जात्यम् ॥

(र.त. 16/2)

स्वर्णतारारताम्रायःपत्राण्यग्नौ प्रतापयेत् ।

निषिञ्चेत्तप्ततप्तानि तैले तक्रे च काञ्जिके ॥

गोमूत्रे च कुलत्थानां कषाये च त्रिधा त्रिधा ।

(शा.सं.मध्यम खण्ड 11/1-2½)

पत्रीकृतं तु रजतं ज्वलने प्रतप्तं

निर्वापयेन्मुनितरोः स्वरसे त्रिवारम् ।

(र.त. 16/6)

Sāmudra Lavaṇa (सामुद्र लवण)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 67

सामुद्रलवणं हृद्यं रुच्यं स्निग्धञ्च दीपनम् ।

सक्षारं भेदि वातघ्नं नात्युष्णं नातिशीतलम् ॥

(र.त. 14/138)

सामुद्रं मधुरं पाके सतिक्तं मधुरं गुरु ।
नात्युष्णं दीपनं भेदि सक्षारमविदाहि च ॥
श्लेष्मलं वातनुत्तीक्ष्णमरूक्षं नातिशीतलम् ॥

(भा.प्र. हरीतक्यादि वर्ग 244-245)

सामुद्रकं समधुरं सतिक्तं कटु पांशुजम् ।
रोचनं लवणं सर्व पाकि स्रंस्यनिलापहम् ।

(च.सं.सू. 27/304)

सामुद्रं मधुरं पाके नात्युष्णमविदाहि च ।
भेदनं स्निग्धमीषच्च शूलघ्नं नातिपित्तलम् ।

(सु.सं.सू. 46/316)

Sauvīrāñjana (सौवीराञ्जन)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 39

स्रोतोञ्जनसमं ज्ञेयं सौवीरं तत्तु पाण्डुरम् ।
अथवा धूम्रवर्णाभं सौवीराञ्जनमुच्यते ॥

(आ.प्र. 2/229)

अञ्जनानि विशुद्ध्यन्ति भृङ्गराजनिजद्रवैः ।

(र.र.स. 3/105)

सौवीरमञ्जनं धूम्रं रक्तपित्तहरं हिमम् ।
विषहिध्मादिरोगघ्नं व्रणशोधनरोपणम् ॥

(र.र.स. 3/100)

सौवीरमञ्जनं ग्राहि स्निग्धञ्च तुहिनोपमम् ।
रक्तपित्तप्रशमनं नेत्रामयहरं परम् ॥
विषहिक्कापहं कामं व्रणशोधनरोपणम् ।
परं रजोरोधकरं रक्तप्रदरनाशनम् ॥

(र.त. 22/45-46)

सौवीरमञ्जनं धूम्रं रक्तपित्तहरं हिमम् ।

वमिहिध्माक्षिरोगघ्नं व्रणशोधनरोपणम् ॥

(र.चू. 11/63)

गुञ्जार्धतः समारभ्य गुञ्जैकमितमञ्जनम् ।

दिनद्वयं त्रयं वापि प्रयुञ्जीत भिषग्वरः ॥

(र.त. 22/47)

अञ्जनद्वितयं रक्तप्रदरे तु दिनत्रयात् ।

अधिकं नोपयुञ्जीत रसतन्त्रविशारदः ॥

(र.त. 22/48)

Svarṇa (स्वर्ण)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 16

दाहे रक्तं सितं छेदे निकषे कुङ्कुमप्रभम् ।

तारशुल्बोज्झितं स्निग्धं कोमलं गुरु हेम सत् ॥

यच्छ्वेतं कठिनं रूक्षं विवर्णं समलं दलम् ।

दाहे छेदे सितं श्वेतं कषे त्याज्यं लघु स्फुटम् ॥

दलं नाम यद् घनाहतं स्फुटति ।

(आ. प्र. 3/23-24)

बालारुणारुणमलं ज्वलनप्रतप्तं

शाणोपले घुसृणचूर्णसमानवर्णम् ।

नाराचिकाधृतमलं गुरुतामुपेयात्

स्निग्धं तदेव कनकं कथितं तु जात्यम् ॥

(र.त. 15/11)

स्वर्णतारारताम्रायःपत्राण्यग्नौ प्रतापयेत् ।
निषिञ्चेत्तप्ततप्तानि तैले तत्रे च काञ्जिके ॥
गोमूत्रे च कुलत्थानां कषाये च त्रिधा त्रिधा ।

(शा.सं.मध्यम खण्ड 11/1-2½)

Svarṇamākṣika (स्वर्णमाक्षिक)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 271

स्निग्धं गुरु श्यामलकान्ति किञ्चित् कषे सुवर्णद्युतिसुप्रकाशम् ।
कोणोज्झितं स्वर्णसमानवर्णं सुवर्णमाक्षीकमिह प्रशस्तम् ॥
(र.त. 21/4)

खरं परं वै गुरुताविहीनं प्रवृत्तकोणं खरलोहकाभम् ।
प्रकीर्तितं तत्परिहेयमेव सुवर्णमाक्षीकमिहामयज्ञैः ॥
(र.त. 21/5)

सुवर्णमाक्षिकं लौहखल्वे तु खलु कुट्टयेत् ।
सुकुट्टितं ततो ज्ञात्वा चालन्यां परिचालयेत् ॥
ततो माक्षिकचूर्णन्तु चालनीपरिगालितम् ।
समादाय कटाहे तु स्थापयेद्भिषजां वरः ॥
निम्बूकस्वरसं दत्त्वा पचेच्चुल्लीगतं ततः ।
दर्व्या सञ्चालयेत्तावद्वावत्स्यादुत्पलप्रभम् ॥
ताप्यं तु यावल्लौहित्यं नैति तावत्प्रयत्नतः ।
पुनर्निम्बूरसं दत्त्वा पचेत्तीव्राग्नियोगतः ॥
भृशं दिनत्रयं वापि द्विदिनं वा विधानतः ।
पाचितं माक्षिकं नूनं शुद्धिमायात्यनुत्तमाम् ॥
(र.त. 21/7-11)

Tāmra (ताम्र)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 22

स्निग्धं मृदु घनं स्वच्छं जपाकुसुमसप्रभम् ।
लोहनागादिरहितं जात्यं ताम्रं प्रकीर्तितम् ॥

(र.त. 17/4)

सदलं पाण्डुरं चैव कठिनं लघु भङ्गुरम् ।
समलं त्वरविन्दन्तु वर्जयेद्रसकर्मणि ॥
घनघातासहं कृष्णं श्वेतं लोहादिसङ्गतम् ।
अतिस्तब्धञ्च रूक्षञ्च ताम्रं त्याज्यं निगद्यते ॥

(र.त.17/5-6)

जपाकुसुमसङ्काशं स्निग्धं मृदु घनक्षमम् ।
लोहनागोज्झितं ताम्रं नेपालं मृत्यवे शुभम् ॥

(आ.प्र. 3/113)

स्वर्णतारारताम्रायःपत्राण्यग्नौ प्रतापयेत् ।
निषिञ्चेत्तप्ततप्तानि तैले तक्ने च काञ्जिके ॥
गोमूत्रे च कुलत्थानां कषाये च त्रिधा त्रिधा ।

(शा.सं.मध्यम खण्ड 11/1-2½)

स्नुह्यर्कक्षीरसिन्धूत्थैस्ताम्रपत्राणि लेपयेत् ।
अग्नौ प्रताप्य निर्गुण्डीरसे संसेचयेत्त्रिंशः ।
स्नुह्यर्कक्षीरसेकैर्वा शुल्बशुद्धिः प्रजायते ॥

(आ.प्र. 3/118-119½)

Taṅkaṇa (टङ्कण)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 72

अतस्तं शोधयेदेव वद्वावुत्फुल्लितः शुचिः ।

(आ.प्र. 2/244)

टङ्कणः कटुरुष्णश्च रूक्षस्तीक्ष्णश्च सारकः ।

कफविश्लेषणो हृद्यो वातामयनिषूदनः ॥

कासश्वासहरः कामं स्थावरादिविषापहः ।

अग्निदीप्तिकरश्चापि भृशमाध्माननाशनः ॥

स्त्रीपुष्पजननो बल्यो विविधव्रणनाशनः ।

पित्तकृच्च समाख्यातो मूढगर्भप्रवर्तकः ॥

(र.त. 13/79-81)

Tuttha (तुत्थ)

द्रव्यगुण विज्ञान भाग - 3 प्रो. प्रियव्रत शर्मा

पृष्ठ 107

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 30

शिखिकण्ठसमच्छायं गुरु स्निग्धं महोज्ज्वलम् ।

तुत्थकं शस्यते विज्ञैरन्यद्धीनगुणं मतम् ॥

(र.त. 21/72)

पीत्वा हालाहलं वान्तं पीतामृतगरुत्मता ।

विषेणामृतयुक्तेन गिरौ मरकताह्वये ॥

तद्वान्तं हि घनीभूतं सञ्जातं सस्यकं खलु ।

मयूरकण्ठसच्छायं भाराढ्यमति शस्यते ॥

(र.र.स. 2/125-126)

रक्तचन्दनमज्जिष्ठावराकवाथेन भावितम् ॥

सप्तवारं प्रयत्नेन शुद्धिमायाति तुत्थकम् ॥

(रसामृतम् 3/74)

तुत्थकं लेखनं भेदि कषायं मधुरं लघु ।
 कृमिघ्नमथ चक्षुष्यं मेहमेदोहरं परम् ॥
 कफपित्तहरं बल्यं शूलहृत्कुष्ठनाशनम् ।
 श्वित्रापहं त्वम्लपित्तहरं चैव रसायनम् ॥
 तुत्थं सङ्कोचनकरं नाडीनां बलकृत् परम् ।
 त्वग्दोषशमनं कामं विशेषाद्बुचिरं मतम् ॥

(र.त. 21/127-129)

लेखनं भेदि च ज्ञेयं तुत्थं कण्डुक्रिमिप्रणुत् ।

(रसे.चि. 7/102)

तुत्थं तु कटुकं क्षारं कषायं वामकं लघु ।
 लेखनं भेदनं शीतं चक्षुष्यं कफपित्तहृत् ॥
 विषाशमकुष्ठकण्डूघ्नं खर्परं चापि तद्गुणम् ।
 वान्तिं भ्रान्तिमशुद्धं तत्कुरुते शोधितं शुभम् ॥

(आ.प्र. 4/38-39)

तुत्थं तु कटुकं क्षारं कषायं वामकं लघु ।
 लेखनं भेदनं चोष्णं चक्षुष्यं कफपित्तहृत् ॥
 विषार्शःकुष्ठकण्डूतिश्वित्रकृमिव्रणापहम् ।

(रसामृत 3/73-73½)

निःशेषदोषविषहृद्गुदशूलशूलदुष्टाम्लपित्तकविबन्धहरं हितञ्च ।
 रसायनं वमनरेककरं गरघ्नं श्वित्रापहं गदितमत्र मयूरतुत्थम् ॥

(र.चू. 10/74)

Vaikrānta (वैक्रान्त)

रसामृतम् - यादवजी त्रिकमजी पृष्ठ 84

अष्टास्रश्चाष्टफलकः षट्कोणो मसृणो गुरुः ।
 शुद्धमिश्रितवर्णैश्च युक्तो वैक्रान्त उच्यते ॥

श्वेतो रक्तश्च पीतश्च नीलः पारावतच्छविः ।
श्यामलः कृष्णवर्णश्च कर्बुरश्चाष्टधा हि सः ।

(र.र.स.2/53-54)

अष्टास्रमष्टफलकं सितपीतासितारुणम् ।
मसृणं गुरु षट्कोणं वैक्रान्तं जात्यमुच्यते ॥
श्वेतो नीलस्तथा रक्तः पीतः पारावतप्रभः ।
ताक्ष्याभः कर्बुरः कृष्णो वर्णतश्चाष्टधा हि सः ॥

(र.त. 23/157-158)

कुलत्थकवाथसंस्विन्नो वैक्रान्तः परिशुद्ध्यति ।

(र.र.स. 2/66)

APPENDIX - 6

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APPENDIX-7

Coloured Photographs of Raw Drugs (Minerals and Metals)

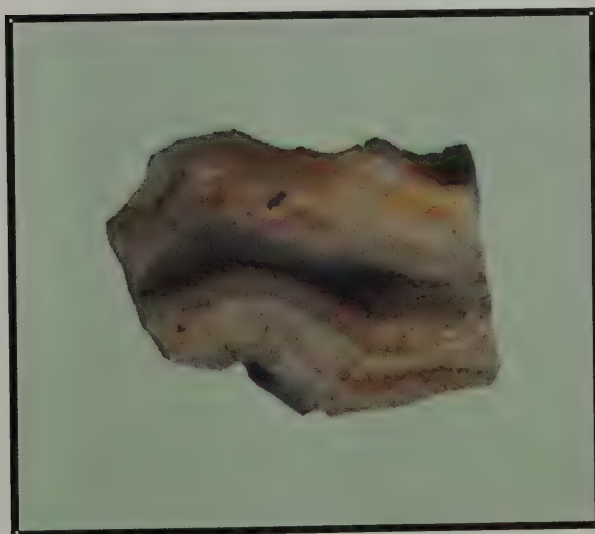
Plate No. 1



Abhraka
(Biotite Mica)

Source – Jaipur Market (Rajasthan)

Plate No. 2



Akika
(Agate)

Source – Khambhat (Gujrat)

Plate No. 3



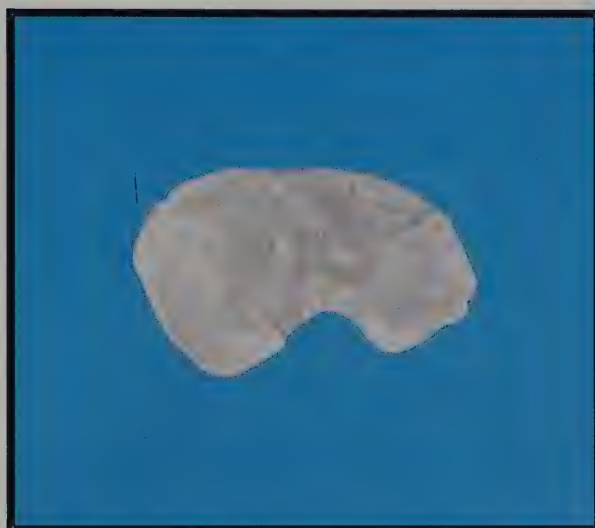
Gairika
(Red Ochre)
Source-Jaipur Market (Rajasthan)

Plate No. 4



Gandhaka
(Sulphur)
Source-Jaipur Market (Rajasthan)

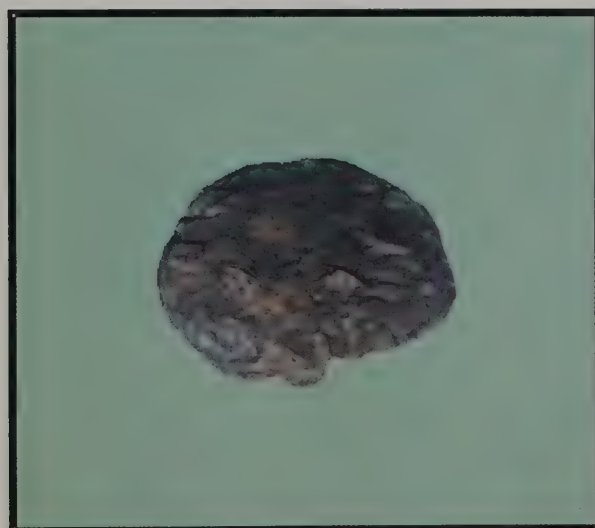
Plate No. 5



Godanti
(Selenite)

Source – Jaipur Market (Rajasthan)

Plate No. 6



Gomeda
(Garnet)

Source – Amet, Rajsamand (Rajasthan)

Plate No. 7



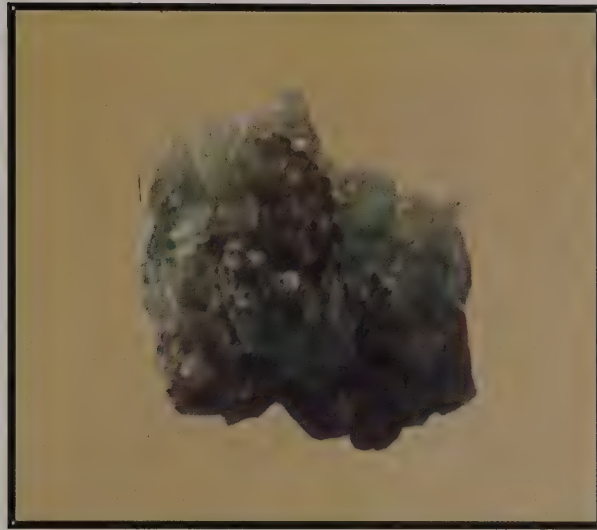
Jaharamoharā
(Serpentine)
Source – Tapan Village,
Near Kherwara
Distt. Udaipur (Rajasthan)

Plate No. 8



Kānta Lauha
(Iron Ore)
Source – Delwara, Udaipur (Rajasthan)

Plate No. 9



Kāśīśa
(Ferrous Sulphate)
Source – Jaipur Market (Rajasthan)

Plate No. 10



Khaṭikā
(Kaolinite)
Source – Jaipur Market (Rajasthan)

Plate No. 11



Maṇḍūra
(Iron Slag)

Source – Singhana, Khetri (Rajasthan)

Plate No. 12



Rajata
(Silver Metal)

Source – Ingot Produced by Hindustan Zinc Ltd.,
Procured From Udaipur (Rajasthan)

Plate No. 13



Sāmudra Lavaṇa
(Sea Salt)
Source – Jaipur Market (Rajasthan)

Plate No. 14



Sauvīrāñjana
(Lead Ore)
Source – Zawar Mine, Udaipur (Rajasthan)

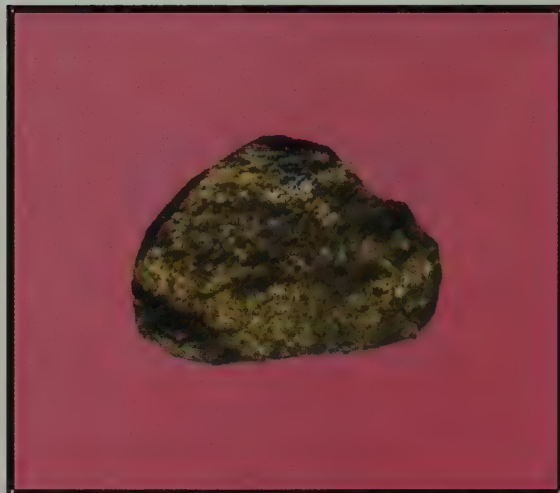
Plate No. 15



Svarṇa
(Gold Metal)

**Source – Ingot from Switzerland
Procured through HDFC Bank, Jaipur (Rajasthan)**

Plate No. 16



Svarṇamākṣika
(Copper Ore)

Source – Khetri Mine (Rajasthan)

Plate No. 17



Svarṇamākṣika - Sāndrita
(Copper Concentrate)

Source – Malanjikhand Copper Project
Hindustan Copper Limited (Madhya Pradesh)

Plate No. 18



Tāmra

(Copper Metal)

Source – Copper Plate Produced by
Hindustan Copper Ltd., Procured From Khetri (Rajasthan)

Plate No. 19



Taṅkaṇa
(Borax)

Source – Jaipur Market (Rajasthan)

Plate No. 20



Tuttha
(Copper Sulphate)

Source – Jaipur Market (Rajasthan)

Plate No. 21



Vaikrānta
(Tourmaline)

**Source – Jawaza Village, Near Beawar,
Distt. Ajmer (Rajasthan)**

PDH.66. Part I, Vol VII
5000-2008 (DSK II)

ISBN 81-905952-2-9



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